POWER PLANT ENGINEERING

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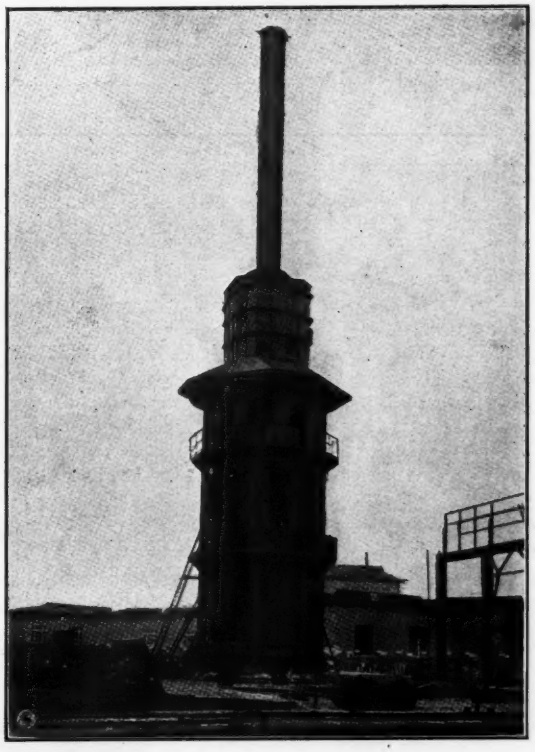


Futurism in Boilers

HERE IT IS! What? It *looks* like a child's imaginings of a combination land-locked lighthouse, a Chinese pagoda, the tower of Pisa and a smokestack. It's hard to believe that it is a serious design for steam making.

But it's an international try at just that. Invented by an Englishman, built in Germany and watched with interest in its trials by French and Americans. Like all scientific advances, it is of universal interest.

And does it work? On page 718 you will find the answer. You will learn what this Benson boiler has been doing and why it is made as it is. The proof of the idea is in its performance. The records may tell whether this is to be the boiler construction of the future.

IF PAGODA TYPE boilers don't interest you, however, perhaps the banquet of the atoms described in this issue will appeal to your imagination. Picture all the big guns of the atomic world gathered together in a family reunion. What a spectacle! What gossip about the radioactive family! What whisperings about the unattached electrons, and the snobbish inert gases—but we must not tell any more; turn to page 728 yourself and get it first hand.

It Pays to Modernize Old Hydro-Electric Plants

COMPARISON OF COSTS AND EFFICIENCIES OF OLD UNITS WITH THOSE OF MODERN DESIGN OFTEN SHOWS NEED OF REMODELING, AS AT HATFIELD, KILBOURN, AND JANESVILLE. BY CLAYTON N. WARD*

USEFUL LIFE OF ALL STRUCTURES and devices built by man has, of course, a definite limit. Deterioration, changes in human needs and inventions and development in mechanical arts are the factors that, collectively or separately, tend to reduce the economic value of all such structures. Certain parts of water power developments, such as dams, canals and buildings, may be affected little by deterioration due to use or to destructive wear and the integrity of such portions may be retained by proper maintenance. Mechanical equipment, however, is subject to all of the influences noted above, which cause a shortening of useful life. Hydraulic turbines built and installed 10 or even 20 yr. ago may have been so designed, constructed and maintained that they perform as efficiently as they ever did but in most cases this is not true. Even in those cases where the original effectiveness has been retained, it may be desirable to replace old equipment with new machines which have higher efficiency, larger capacity, greater reliability and are thus more economical to operate than the old machines.

Individual hydro-electric plants must not only compete in the power market with other water power plants but with plants powered by such prime movers as the steam engine or turbine and the oil engine. In the last twenty years, improvements in steam prime movers have reduced the average B.t.u. required per kilowatt-hour from 37,500 to 16,000. Inventions and improvements in other fields have thus tended to reduce the relative effectiveness of existing water power equipment. Rebuilding of certain portions of an existing hydro-electric plant and the replacement of machines are justified when the net income from the remodeled plant exceeds that of the old plant by an amount sufficient to pay interest and depreciation charges on the new investment.

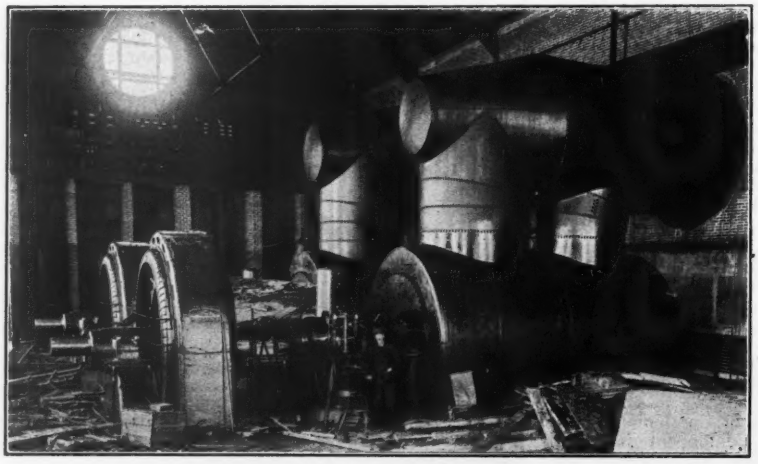


FIG. 1 (LEFT). TWO DOUBLE-RUNNER HORIZONTAL UNITS, EACH DRIVING A 3200-KW. GENERATOR, FORMED THE ORIGINAL INSTALLATION AT HATFIELD BEFORE REMODELING WAS UNDERTAKEN. THIS VIEW WAS TAKEN JUST AFTER A SEVERE FLOOD THAT OVER-TOPPED THE DAM AND COVERED THE POWER HOUSE FLOOR WITH DEBRIS

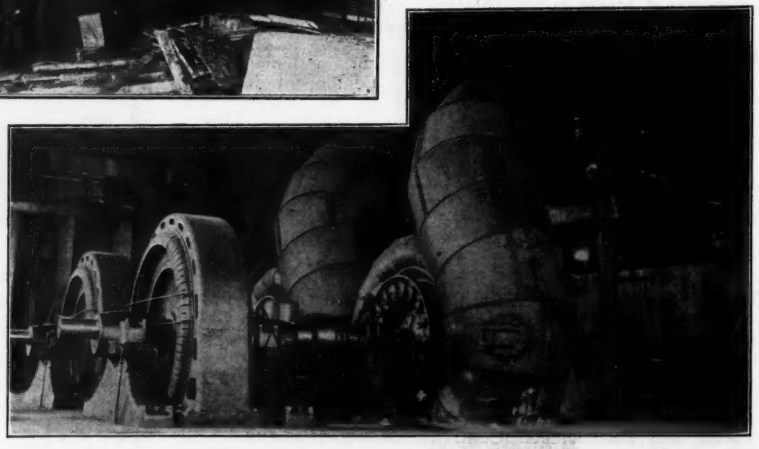


FIG. 2 (RIGHT). AFTER REMODELING IN 1926 AND 1927, HATFIELD PLANT APPEARED THUS. ORIGINAL GENERATORS WERE RETAINED BUT EACH IS NOW DRIVEN BY A NEW SINGLE-RUNNER, 4270-HP. HORIZONTAL TURBINE. THESE UNITS INCREASE BOTH OUTPUT AND EFFICIENCY MORE THAN 20 PER CENT.

Recently, the organization with which the writer is connected has had occasion to rebuild several water power plants and to replace the water wheels and electric generators in other plants. Tests were run on certain of these old units before they were dismantled and later similar tests were made on the new units so that actual

*Engineer with Mead & Seastone, Consulting Engineers, Madison, Wis.

relative performance could be determined. Following is a brief review of the general problems involved in several of these changes and the results obtained.

Modernizing the Hatfield Plant

Hatfield development, now owned and operated by the Mississippi Valley Public Service Co., is located on the Black River at Hatfield, Wis., about 11 mi. north of Black River Falls. This plant operates in conjunction with a steam plant at Winona, Minn. The drainage area above Hatfield is about 1200 sq. mi. and the development consists of a dam, having a maximum height of about 49 ft., which creates a reservoir of 650 acres, a canal 2½ mi. long, two 10-ft. and one 35-in. penstocks, each about 260 ft. long, and the power house and equipment. The original generating installation consisted of two 3200-kw. generators, each of which was directly connected to a horizontal-shaft hydraulic turbine consisting of two 39-in. wheels discharging into a common central draft tube. Two exciter units are each driven by a 250-hp. hydraulic turbine. The Black River drainage area above Hatfield is narrow and the character of the geological structure and the steepness of the slopes are such that the river is subject to high flood stages and to comparatively low sustained flows during portions of the year; for these reasons, conditions are not favorable for the development of hydro power.

Casing of Unit No. 1 Failed Twice in Same Place

Arrangement of the equipment as originally installed is illustrated in Fig. 1. The turbine case of unit No. 1 failed in 1920 through bursting of the horizontal joint at the base plate and ripping of the circumferential riveted joint in the steel casing, as shown in Fig. 3. The accident was attributed to the severe conditions to which the penstock and the turbine case were subjected when the unbalanced turbine gates closed suddenly. The turbine case consisted of a cylindrical steel plate riveted to a cast-iron base. The cast-iron base failed along the

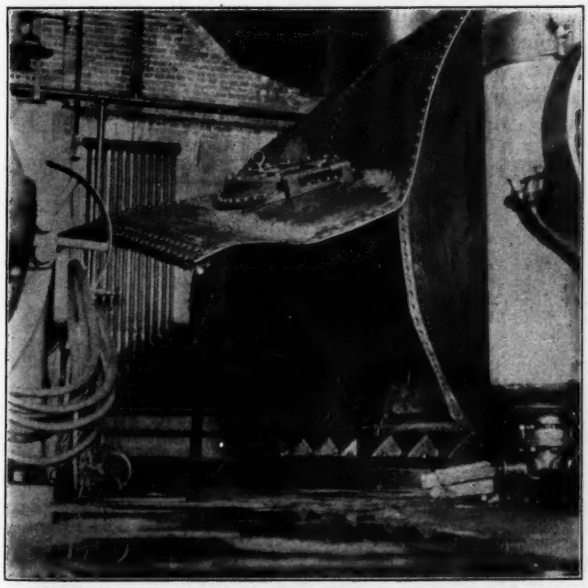


FIG. 3. IN 1920, CASING OF OLD UNIT NO. 1 FAILED NEAR BASE PLATE. IT WAS REPAIRED AND RUN UNTIL 1926

FIG. 4. IN MARCH, 1926, CASING OF OLD UNIT NO. 1 FAILED AGAIN AT SAME PLACE AS IN 1920

line of rivet holes on one side of the base where the steel plates joined it. After the failure, a new line of holes was drilled in the cast-iron base (a sufficient length of the projecting side remained to permit this) and the steel plates were again riveted to the base. As an added precaution, bolts were tapped into the base and attached to the sides of the shell. The penstock was jacked back into shape and the unit was again placed in operation.

In March, 1926, the same unit failed again on the same side as before (see Fig. 4). It will be noted that the second break involved not only the base casing and riveted joints but also the rear end casting of the turbine case. It appeared that if there was any unusual pressure on the casing it was brought about by the governor action but recording instruments did not indicate any marked changes in the turbine output. Figure 5 illustrates the condition of the penstock which resulted from the failure.

Samples of the cast-iron base were tested and were found to be relatively weak. An analysis of stress in the casting, due to direct tension and to the eccentricity of the load, indicated that the connection to the base never was safe. The difficulty in securing and placing a new cast steel base, its cost and the general condition of the turbine, made it inadvisable to attempt another

FIG. 5. COLLAPSE OF PENSTOCK THAT ACCOMPANIED SECOND FAILURE OF UNIT NO. 1, MARCH, 1926

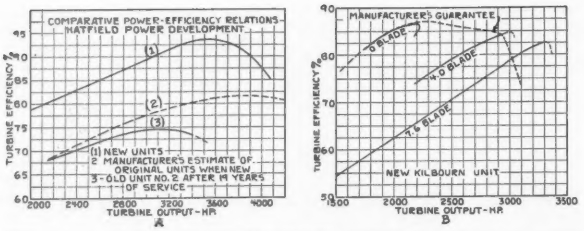


FIG. 6. A—POWER EFFICIENCY CURVES OF OLD UNIT NO. 2 AND NEW UNITS AT HATFIELD. B—POWER EFFICIENCY CURVES FOR THREE ADJUSTMENTS OF NEW UNIT AT KILBOURN

repair; accordingly, it was decided to purchase a new turbine. The question then arose as to the safety of the turbine of unit No. 2.

Unit No. 2 Was Reenforced Pending Replacement

Subsequent examination showed that at some time in the past an attempt had been made to reinforce that turbine casing and there was evidence that a failure had started there. Although that unit had been running for several years without apparent trouble, the engineers would not assume the responsibility of approving its further use, even during the period of installation of a new turbine, unless it could be reinforced. This turbine (unit No. 2) was reinforced with steel bars anchored in the floor and imbedded in large blocks of concrete on each side of the casing. Steel tie rods were attached to the inside of the casing wall and at the base. After these precautions were taken, the turbine was allowed to operate during the period of the installation of unit No. 1.

For each of the units a 4270-hp., 300-r.p.m., single-runner, horizontal-shaft turbine was ordered; the new turbines were directly connected to the old generators, the settings of which were not altered. Figure 2 shows the new units.

Results of Tests on Old and New Units

During the erection of the new turbine, unit No. 1, a test was run on old unit No. 2. Flow measurements were made between the piers at the outlet of the draft tube pit with an Ott current meter. Power output was measured with carefully calibrated electrical meters on the switchboard. A few weeks after the first new unit was put into operation, a test was run on it. While conditions were not ideal for the use of a current meter, the consistency of the results obtained indicated reasonable accuracy; furthermore, since the old turbine and the new turbine were tested under similar conditions, the results obtained were at least comparable.

No test of the old units was made at the time they were installed so that all we have to indicate their probable performance is the manufacturer's estimated power-efficiency curve. The manufacturer stated in 1914 that tests were never made on this particular wheel and that the performance estimates were deduced from information on tests of other wheels. It seems that the manufacturer overestimated the power at and near full gate. Maximum efficiency of about 82 per cent was expected of the old wheels. Figure 6A shows the power-efficiency curve of old unit No. 2 after about 19 yr. of use, together with the manufacturer's estimated curve for the original units.

While the replacement of the old equipment was prompted by considerations of safety and reliability of the machines, it is evident that a purely economic study based only upon efficiencies of the old units and efficiencies obtainable with new turbines would have proved the desirability of removing the old turbines. Efficiency of the new machine exceeds that of the old, from one-half capacity to the point of maximum efficiency of the new machine, by an average of about 16½ per cent. Average efficiency of the old unit over the above range is about 70 per cent, so that the average increase is more than 23½ per cent of the average efficiency attainable with the old machines through this range. During the high-water stages, when water is wasted, there is a further substantial advantage with the new turbines because of their relatively greater capacity. At such times, efficiency is of no value except as it affects the capacity of the turbine. Under similar conditions of river flow and power demand, the annual output with the new units should exceed that of the old units by at least 20 per cent.

Operation of New Hatfield Units

These new machines were set higher than they would have been placed had they been installed in a new plant. Often, in such replacements, there are numerous existing parts of the plant which make it impracticable to install new machinery in the most effective manner. At Hatfield, the draft-tube pit was somewhat too shallow but the time required, the expense and the possibility of weakening other parts of the plant made it inadvisable to deepen the pit. It is apparent that this particular setting has not materially reduced the efficiency of the turbine, although it may have an effect on the maintenance of the wheel.

At certain particular loads on the new unit, it was discovered that the conditions of turbine operation set up a pressure disturbance which was manifested in a periodic distortion of startling magnitude in the penstock shell. This condition was entirely relieved by the admission of a small quantity of air to the center of the turbine through two pipes, controlled by a simple check valve.

Kilbourn hydro-electric plant, built by the Southern Wisconsin Power Co. and now owned and operated by

FIG. 7. GENERAL ARRANGEMENT OF ORIGINAL UNITS AT KILBOURN

the Wisconsin Power and Light Co., is located on the Wisconsin River at Kilbourn, Wis. The drainage area above the plant is about 7865 sq. mi. and the normal operating head is 21 ft.

Bringing Kilbourn Plant Up to Date

Original installation, made in 1908, consisted of 2778-hp., horizontal hydraulic turbines, each directly connected to a 1500-kw., 100-r.p.m., 3-phase, 25-cycle generator designed for temperature rise of 40 deg. C. Each turbine had six 57-in. water wheels connected to a horizontal shaft, arranged so that the discharge from the two end wheels was carried through separate or individual quarter-turns and draft tubes, the inner four wheels being arranged to discharge in pairs into two quarter-turns and draft tubes. Excitation was provided by two generators, each driven by a hydraulic turbine having two 33-in. wheels. General arrangement of the original units is illustrated in Fig. 7. Figure 8 shows the original water wheels, with a diaphragm or "umbrella" supported on the casing over the gates to prevent admission of air through vortices.

In 1925, the power company decided to replace one unit with a modern turbine and a 60-cycle electric generator. A vertical unit, Fig. 9, was selected; this consists of turbine with a single four-bladed, propeller-type runner, direct-connected to a 2750-kv.a., 138½-r.p.m., 60-cycle generator. On the turbine, a provision for variable flow permits changes to be made so that the range of relatively high efficiency of the turbine may be greatly increased for varying load and heads as compared with turbines in which this adjustment cannot be made. During flood times when the operating head is greatly reduced and water is plentiful, adjustment may be made so as to increase materially the capacity of the wheel. To make this adjustment requires the turbine to be shut down for only 5 or 10 min.; it is a simple operation and does not require draining of pits.

Methods of testing at Kilbourn were similar to those at Hatfield excepting that the flow measurements were made by an Ott current meter a short distance below the trash racks in the plane of the head gate openings. The conditions for current meter observations were less

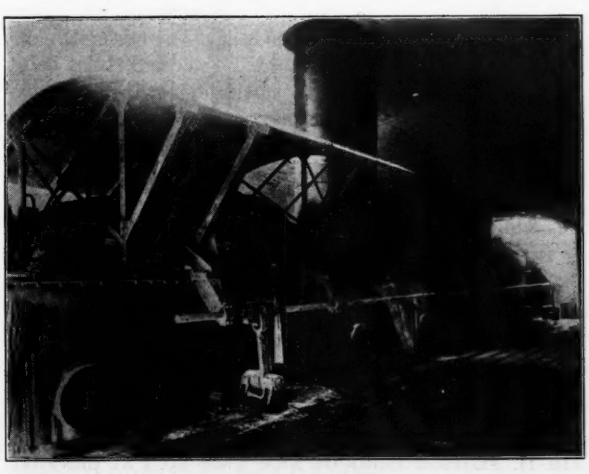


FIG. 8. AT KILBOURN, EACH 1500-KW. GENERATOR WAS ORIGINALLY DRIVEN BY A TURBINE HAVING SIX HORIZONTAL WHEELS ON A COMMON SHAFT. "UMBRELLA" OVER CASING WAS TO PREVENT AIR ADMISSION

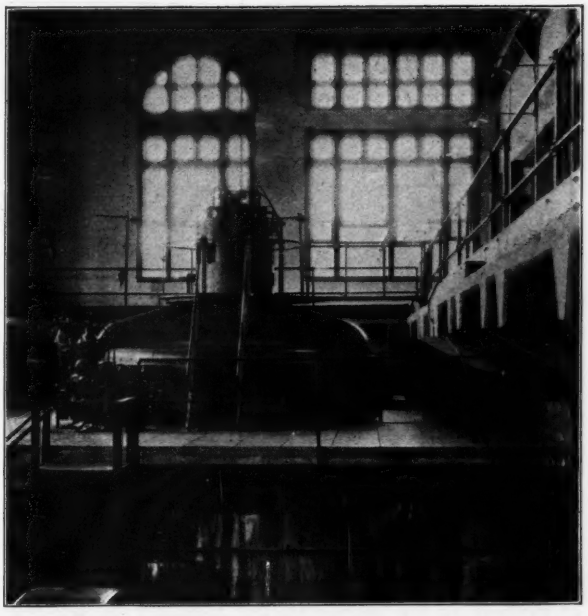


FIG. 9. ONE OF THE OLD KILBOURN UNITS WAS REPLACED BY THIS MODERN MACHINE, A PROPELLER-RUNNER, VERTICAL TURBINE DRIVING A 2750-KV.A. GENERATOR

favorable than those at Hatfield, because of greater turbulence of flow. There are three gate openings for each turbine, each opening being about 11 ft. wide and 18 ft. deep. Since but one meter was used, some error may have been introduced due to possible changes in distribution of flow through the openings during the period of a run. A check was made by independent observers with another Ott meter during one test and the results of the two observations agreed very well. Efficiency-power relations for the new unit are shown on Fig. 6B.

In the field test of the machine as set, runs were taken with various adjustments of 0, 4.0 and 7.6, as indicated by a pointer on a graduated arc located on the turbine shaft. The three solid curves of Fig. 6B represent the respective performances. The complete range, of course, would require tests at additional adjustments. Efficiencies attainable for various turbine outputs would then be read from an envelope of efficiency-power curves.

Results of Tests on Kilbourn Units

Test of the old units, made when they were new, was at a head different from that under which the new unit was tested and no tests were run on the old unit after the acceptance test in 1910. For a head of 21 ft., the new single-runner turbine efficiency exceeds that of the old 6-runner unit under the same head when new (as indicated by Holyoke tests) on an average of about 14 per cent for a range of output from 1600 to 3000 hp., which represents an increase of over 20 per cent expressed as a percentage of the average efficiency of the old unit. Due to deterioration of the old unit, it is probable that the efficiency of the new unit exceeds that of the old unit at the time the latter was dismantled by considerably more than 14 per cent.

Maintenance of the old units was difficult because of the inaccessibility of parts subject to wear, while con-

FIG. 10. SHAFT FROM THE OLD KILBOURN UNIT THAT WAS REPLACED, SHOWING BREAK THAT OCCURRED WHEN IT WAS DROPPED FROM A FLAT CAR

tinuity of service had been interrupted by the loosening of runners on the turbine shaft. Figure 10 is a photograph of the shaft of the old turbine and shows a break which occurred when the shaft was dropped a short distance from a flat car. It is probable that an interruption of service, if not a serious accident, might have occurred if this shaft had been continued in operation.

Remodeling Two Low-Head Janesville Plants

Wisconsin Power and Light Co. owns several small hydro-electric plants on the Rock River. One, known as the Central Plant, is located near the business district of Janesville, Wis., and another, known as the Monterey Plant, is situated about 2½ mi. downstream. The drainage area of the Rock River above Janesville is about 3100 sq. mi. The Monterey Plant was rebuilt in 1925 and 1926 and the Central Plant in 1927.

At Monterey, the old installation consisted of five water wheels, each 66-in. in diameter, operated at 75 r.p.m. The normal head is about 9 ft. Power was transmitted from the wheels through bevel gears to a horizontal line shaft, to which was belted a 400-kw. generator. In 1925, three of the old wheels and their substructure were removed and a new 240-hp., vertical, propeller-type turbine was installed in a vacuum setting. The new turbine is directly connected to a 200-kv.a. generator. Excitation is provided by a belt-driven 11-kw. exciter.

In 1918, a test was made of four old units of the Monterey plant at two different gate openings. Efficiencies were obtained for the entire plant by dividing

TABLE I. GUARANTEED TURBINE EFFICIENCIES OF NEW UNIT AT MONTEREY PLANT

Turbine output, hp.	Efficiency of turbine, manufacturer's guarantee, per cent
240	84.0
225	86.5
192	82.0
144	75.0
96	60.0

TABLE II. RESULTS OF TESTS ON SIX OLD UNITS AT JANESVILLE CENTRAL, BEFORE REPLACEMENT

Year of test	Gate Opening	Power output, kw.	Plant efficiency, per cent
1918	Full	340.2	51.1
	¾	295.5	50.3
	½	162.5	35.7
1925	¾	257.0	43.0
	½	124.0	28.6

the output measured at the switchboard by the water horsepower; no attempt was made to segregate the losses in the various parts up to the switchboard. The overall efficiency at ¾ gate was 56.4 per cent and the output was 234 kw.; at full gate, efficiency was 52 per cent and output 293 kw. The new unit has not been tested but the manufacturer's guarantee of turbine efficiency is given in Table I.

According to the guaranteed generator efficiencies and allowing 2 per cent for excitation and losses between generator and switchboard, the new unit should have a maximum overall efficiency of about 75 per cent, and an average efficiency, from one-half to full load, of about 66 per cent. The average overall efficiency of the old unit in 1918 from one-half to full load was approximately 50 per cent. There was undoubtedly deterioration between 1918 and 1925 so that the average efficiency of the old unit just prior to its removal was probably less than 50 per cent. Under normal conditions, the new unit should deliver more than 40 per cent more energy than the old unit. The new unit has the additional advantage of higher efficiencies under reduced heads and the ability to continue to operate when the head is reduced to less than one-half of the normal.

Central Plant at Janesville originally contained six vertical turbines, harnessed through crown gears and line shaft to drive two generators having respective capacities of 275 and 85 kw. Normal operating head is about 8.5 ft. In 1918 and 1925, tests were made on the

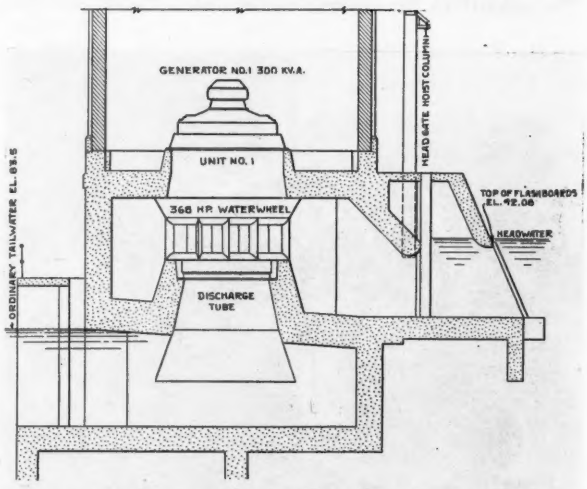


FIG. 11. SECTION THROUGH NEW UNIT NO. 1 AT CENTRAL PLANT, JANESVILLE. VACUUM SETTING WAS USED TO REDUCE EXCAVATION, BECAUSE OF CONSTRUCTION DIFFICULTIES AND TO INCREASE EFFECTIVE DRAFT TUBE LENGTH

old units and the comparative results are shown in Table II. Efficiencies are computed from output measured at the switchboard divided by the water horsepower. During the seven years, the 6 units lost about 7 per cent in overall efficiency at both ¾ and ½ turbine gate openings.

This plant also has now been reconstructed. The new equipment consists of two 57-in. vertical wheels of 368 hp. each, at 120 r.p.m., under 8.5-ft. head. Each is directly connected to a 300-kv.a. generator with direct-connected exciter. Figure 11 is a cross-section through Central Plant, showing the vacuum setting of the wheels. Best guaranteed overall efficiency of the new units is about 77 per cent, which is 34 per cent greater than that attained with the old units or 79 per cent greater when expressed as a percentage of the old unit efficiency. Average overall efficiency from one-half to full power is estimated at about 69 per cent, while that of the old units was approximately 40 per cent.

Savings Indicated Show Advisability of Remodeling

There can be little question as to the advisability of replacing worn and obsolete equipment when savings such as indicated in the above examples are possible. Public interest in conservation is involved, as well as the question of the earning power of the plant for the owner. In many instances, little attention is given to such questions in plants where the need for a change is most apparent. An owner who has received inadequate returns from an investment already made in a water power plant is likely to be skeptical about increasing his investment, although a relatively small additional expenditure might easily make the plant a successful enterprise.

Industrial Wastes Affect Plant Water Supply

Part I. Survey of River Showed How Waste Products Discharged to It Affected Operation of the Condensers of Steam Station Downstream†. Methods Were Then Devised to Overcome the Trouble. By D. C. Carmichael*

EFFECT OF INDUSTRIAL waste emptying into large streams is a question that is continually influencing the feedwater treatment and condenser operation of many large power generating stations. This pollution is especially noticed around the steel mill district, also in districts where only one supply of water, which is highly contaminated, is used for cooling purposes in the surface condenser and also is the source of the makeup water for boiler feed purposes.

Principal industrial waste pollution from steel mills is usually the refuse from the pickling bath, which may have a high acid content, either in the form of free acid or as ferrous sulphate, which is hydrolized to free acid and ferrous hydrate. This waste often results in high operation and maintenance cost of steam stations due to the following causes:

1. Corrosion of steam boilers, surface condensers and other equipment as a result of acid wastes discharged into streams.
2. Deposits in surface condensers as a result of suspended solids discharged into the stream with the waste.

Many of these problems are extremely difficult to control, since the cost of treatment would impose great hardship on those responsible for the pollution and also might cause legal complications.

Effect of Stream Pollution on Surface Condenser Cooling Water

Foregoing effects of pollution in a stream used for condenser cooling water, as well as makeup, were clearly pointed out in a survey supervised by the writer. The stream had been polluted to such an extent that it had cost this particular generating station a large sum of money in loss of efficiency and replacement to piping, tanks and boilers, for cleaning the surface condenser and removing the iron oxide from the tubes.

Before the writer made the survey, the stream had been intermittently showing acid but, when the steel mill above the station began full operation, contamination was encountered continuously. To collect data to show the source of the pollution, sampling points were located at points beginning above the steel plant and extending on below the generating station, including all the tributaries between these two points. Locations of the sampling points on the main body of the stream or river and tributaries are shown in Fig. 1. Locations were such that all discharge water from any plants emptying into the stream was also tested. Samples were collected every four hours for four days, at the end of which time the stream was free from acid because the steel plant was shut down over Sunday.

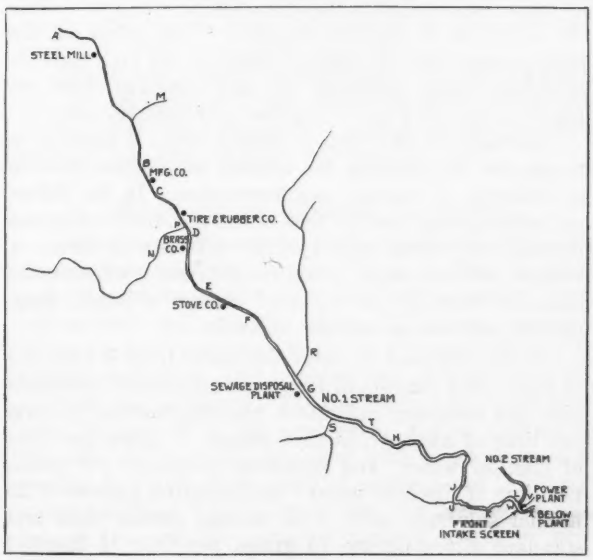


FIG. 1. LOCATION OF SAMPLING POINTS ON RIVER UNDER SURVEY

*Cyrus Wm. Rice & Co., Pittsburgh, Pa.
†Part II of this article will discuss effects of stream pollution on boiler feedwater and methods of treatment used.

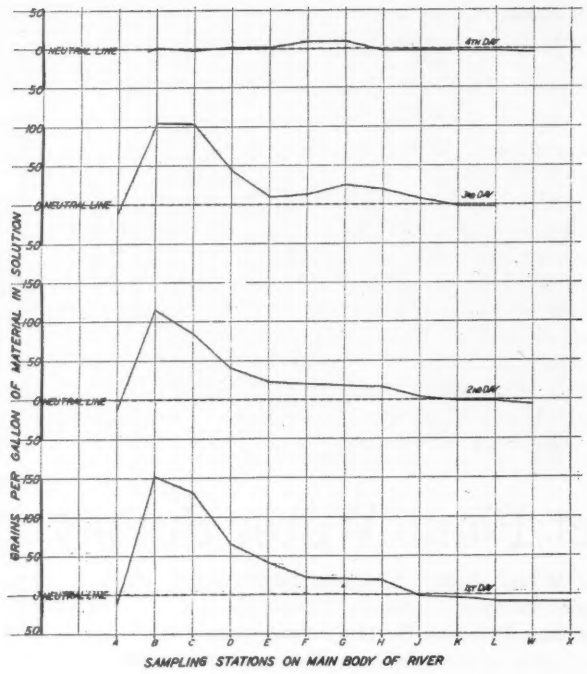


FIG. 2. CHART SHOWING GRAINS OF ACID AND BICARBONATE ALKALINITY. ACID CONTENT ABOVE NEUTRAL LINE, BICARBONATE BELOW

Tests were made on each sample of water for the following constituents: 1—temporary hardness (bicarbonates of calcium and magnesium); 2—total acid content; 3—chlorides (magnesium, calcium or sodium chloride). In reporting the tests, no distinction was made between the content of calcium and magnesium bicarbonates, as both constituents are included under the single term temporary hardness or methyl orange alkalinity. When any of the water samples showed temporary hardness, no acid was present, which was the case in all the tributaries of No. 1 stream and also the discharge from No. 2 stream.

Total acid included the free sulphuric acid as well as the acid due to ferrous sulphate. The effect of the acid present was the same whether in the free state or combined form, therefore all acid readings were reported in grains per U. S. gallon of sulphuric acid.

Chloride, or salt test, is simply what it implies—a means for determining the amount of sodium chloride or chlorides of calcium and magnesium. In the different tables giving various tests of the amount of chlorides present, the reader may consider all tests in terms of sodium chloride, as it made no difference whether the chlorides were in the form of sodium chloride, magnesium chloride or calcium chloride.

Apparatus used to carry out these tests is pictured in Fig. 5 and consists of two burettes, a white porcelain dish, the necessary indicators, phenolphthalein (1 gram per liter of alcohol), methyl orange (1 gram per liter of distilled water) and potassium chromate (50 grams per liter of distilled water) and titrating agents—1/25 normal sulphuric acid, 1/25 normal caustic soda and standard silver nitrate (5 grams per liter of distilled water). These tests are covered in steps in the detailed directions given elsewhere in this article.

DETAILED DIRECTIONS FOR TESTING WATER SAMPLES

Before proceeding with step 1, two drops of methyl orange indicator were added to approximately a 25-c.c. portion of the water to be tested. If the water sample changed to an orange color, acid was present but if the indicator changed the sample to a yellow color, either bicarbonates of calcium or magnesium were present, thus showing the water to contain temporary hardness. The sample was then tested and directions for making this test follow:

1. Measure out 100 c.c. of water.

2. Pour into porcelain dish and if the sample had changed orange with methyl orange indicator in the preliminary test, acid was present. Bring the 100-c.c. sample to the boiling temperature and add 5 drops of phenolphthalein indicator.

3. Fill the burette to zero mark with twenty-fifth normal caustic soda and gradually add (titrate) the caustic soda to the water until a pink color appears. This reading, times the factor 1.16, gives the total acid in grains per U. S. gallon of sulphuric acid.

4. If the sample of water showed temporary hardness present, the methyl orange indicator is used in place of phenolphthalein.

5. Pour the 100-c.c. sample into the porcelain dish and add two drops of methyl orange indicator. This will turn the water a yellow color.

6. Fill the burette to zero mark with twenty-fifth normal sulphuric acid and gradually add (titrate) the acid to the water until the yellow color just changes to an orange. This reading, times the factor 1.23, gives the temporary hardness or methyl orange alkalinity.

7. To another 100 c.c. of the same water, add 10 drops of potassium chromate indicator. This will turn the water yellow.

8. Fill the second burette to the zero mark with standard silver nitrate.

9. Add (titrate) silver nitrate slowly from the burette. Approaching the end point, a red color will appear and then disappear with each addition of silver nitrate. Continue the titration until the red color just stays permanent, giving the sample a faint brownish red tinge. This is the end point and the number of cubic centimeters of silver nitrate used represents grains per gallon of salt when the original water sample was 100 c.c.

Results of these tests are shown in Fig. 2, in which is plotted the increase in acid content of the sampling stations on the main body of the stream. As may be noted in Fig. 1, sampling point A is above the steel plant and B is the first point of sample collection below the plant. The curves for the first three days show much the same trend, while the acid content of the fourth day was almost nothing as the steel plant was not working on Sunday.

Figure 3 shows the variations of the permanent hard-

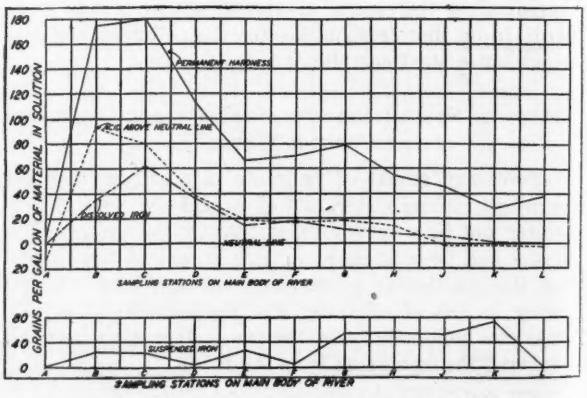

PERMANENT HARDNESS
ACID ABOVE NEUTRAL LINE
DISSOLVED IRON
NEUTRAL LINE
GRAINS PER GALLON OF MATERIAL IN SOLUTION
SAMPLING STATIONS ON MAIN BODY OF RIVER
SUSPENDED IRON
SAMPLING STATIONS ON MAIN BODY OF RIVER

FIG. 3. CHART SHOWING DIFFERENCE IN CONSTITUENTS OF COMPOSITE SAMPLES FROM EACH STATION

ness, acid content and dissolved and suspended iron of composite samples from each 4-hr. collection. Acid content and dissolved iron follow the same trend, due to a large percentage of the sulphuric acid being in chemical combination with the iron as ferrous sulphate, while the suspended iron content differed according to the volume of water from each tributary.

Inasmuch as all the tributaries showed temporary hardness (calcium and magnesium bicarbonate) to be present, the ferrous sulphate was precipitated and thus

TABLE I. PERCENTAGE INCREASE OF POLLUTING CONSTITUENTS AS COMPARED WITH SAMPLE TAKEN AT POINT A, NO. 1 STREAM

Sampling Station	Acid	Dissolved Iron	Permanent Hardness	Chlorides	Suspended Iron Grs. per U. S. Gal.
B	790%	3500%	4400%	350%	0.0
C	700	6200	4500	282	24.0
D	380	3600	2800	330	23.0
E	242	1400	1650	400	4.0
F	224	1800	1750	698	27.0
G	332	1100	1975	450	5.0
H	205	800	1350	385	54.0
J	89	600	1125	385	55.0
K	88	100	700	385	53.0
L	79	0	950	310	74.0
W			Front of Intake Screen		54.0
X			Below Power Plant		26.0

TABLE II. LABORATORY ANALYSIS OF COMPOSITE WATER SAMPLES COLLECTED AT DIFFERENT SAMPLING POINTS ON NO. 1 STREAM. ALL QUANTITIES IN GRAINS PER U. S. GALLON

Station	Permanent Hardness	Dissolved Iron	Alkalinity	Acid
A	4.0	0.0	13.5*	0.0**
B	176.0	35.0	0.0	93.0
C	180.0	62.0	0.0	80.2
D	112.0	36.0	0.0	38.0
E	66.0	14.0	0.0	19.2
F	70.0	18.0	0.0	16.7
G	79.0	11.0	0.0	17.0
H	54.0	8.0	0.0	14.0
J	45.0	6.0	1.2	0.0
K	28.0	1.0	1.7	0.0
L	38.0	0.0	2.8	0.0

* Bicarbonates of calcium and magnesium ** Sulphuric Acid.

TABLE III. LABORATORY ANALYSIS OF SAMPLES FROM NO. 2 STREAM SHOWING ABSENCE OF POLLUTION. ALL QUANTITIES IN GRAINS PER U. S. GALLON

Temporary Hardness	10.2 gr.	Magnesium Chloride	nil
Permanent Hardness	2.8	Calcium Chloride	nil
Calcium Carbonate	10.2	Sodium Chloride	.7
Magnesium Carbonate	nil	Sodium Sulphate	3.2
Calcium Sulphate	nil	Silica	2.8
Magnesium Sulphate	3.4	Iron & Alumina	trace
		Total solids	20.3

the suspended iron differed according to the volume of water flowing into the main stream from the tributaries.

Table I shows the percentage increase of the various constituents at the different sampling stations over the amount present in the samples collected at point A. This table demonstrates plainly that the major contamination was coming from the steel mill, as there was a most decided decrease in impurities of each set of samples after station B. Table I also shows the grains per gallon of suspended iron in the main body of the stream. The increase at sampling point W was on account of another smaller stream mixing with No. 1 stream above the power plant. This stream (marked No. 2 stream, Fig. 1) contained a large amount of temporary hardness which precipitated the iron. The samples from W were of the combined streams and the sampling location was immediately in front of the intake screen to the surface condenser. Station X was below the power plant and the difference in amounts of suspended iron between samples collected at W and X gives a general idea of the amount deposited on the tubes of the surface condenser.

Table II shows the results of the laboratory analyses of the various constituents made on composite water samples as collected at the different sampling points.

Table III is a laboratory analysis of a yearly composite sample from No. 2 stream. It may be noted that this stream always showed a high content of temporary hardness to be present, and therefore no acid, either combined or free.

Effect of Iron Oxide Deposits on Surface Condenser Tubes

Due to the pollution of the stream, iron oxide was carried in the cooling water and a large percentage deposited on the condenser tubes of the power plant. These deposits caused a large amount of trouble, and the losses may be enumerated as follows: decrease in heat transfer; drop or trouble in maintaining vacuum, which

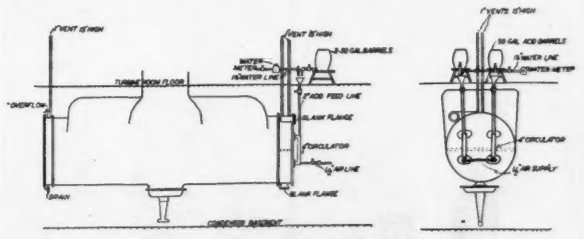


FIG. 4. PIPING ARRANGEMENT FOR INTRODUCTION AND CIRCULATION OF MURIATIC ACID SOLUTION FOR CLEANING SURFACE CONDENSER

meant heat loss with possible outage in equipment; shorter intervals between cleaning periods, which meant increased maintenance costs, also decreasing length of life of condenser tubes, due to mechanical or chemical action on tube metal; galvanic action due to deposits, which in turn would cause shorter life of condenser tubes and result finally in the failure of the tubes. These losses need no elaborate explanation, as they are self-evident to any power plant engineer.

Mechanical cleaning methods were used at this plant, but did not meet with any decided success, so with this fact in view, a 5 per cent hydrochloric (muriatic) acid solution was decided upon as treatment.

Equipment for Treating Condenser

Piping arrangements for introducing and circulating the muriatic acid solution are shown in Fig. 4. Four 1-in. holes were drilled in the top of the water boxes, two at each end, and 1-in. pipes, 12 ft. long, were put in for vents. These later had to be increased about 3 ft. to take care of the acid bubbling out of them when the solution was circulated. The suction and discharge were both blanked off at the condenser. Before putting in the acid, all the tubes were shot with bullet cleaners to remove as much of the scale as possible and the steam space was filled with water so that any leakage of acid into it through the tubes or packing would be neutralized.

Acid and water were fed in at a constant rate, so

that the solution was of 5 per cent strength at all times. A 1¼-in. keystone meter was used to measure the flow of water while the acid was poured into the 50-gal. wooden barrels. Valves were installed to regulate the flow of acid and water and the mixtures were introduced into the condenser through the top of the circulators.

Acid was circulated through two 4-in. circulators shown in the figure. The valves in the pipe through which the acid was being fed were first closed and the ½-in. compressed air lines opened to circulate the mixture. After 12 hr., the steel pipe, of which the circulators were made up, was found to be badly eaten and the circulators were therefore stopped. The solution was left in for 16 hr., drained out, the heads taken off and the condenser examined. The bottom halves of the tubes

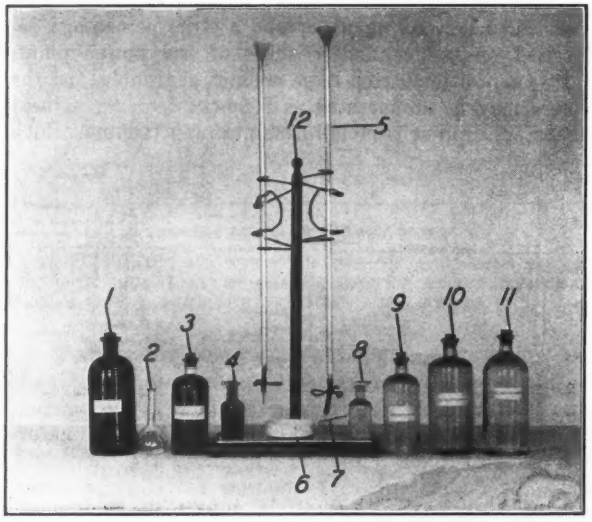


FIG. 5. APPARATUS USED IN TESTING THE VARIOUS WATER SAMPLES COLLECTED

1—Silver nitrate solution. 2—Measuring flask, 100 c.c. 3—Stock supply of potassium chromate solution. 4—Dropper bottle with potassium chromate solution. 5—Burette. 6—White porcelain titrating dish. 7—Glass stirring rod. 8—Dropper bottle with phenolphthalein solution. 9—Stock supply of phenolphthalein solution. 10—Bottle of standard N/25 sulphuric acid for titrating. 11—Bottle of standard N/25 caustic soda for titrating. 12—Burette stand.

were found to be cleaned thoroughly, though some scale remained in the top. This was probably due to the gas in the top of the tubes driving the acid out, which was in turn caused by circulation being insufficient. The tube sheet and cast-iron heads and water boxes were cleaned thoroughly by the acid.

Three tube failures were found. In all three cases, the hole occurred somewhere along a groove in the tube that had apparently been made by the scrapers used in cleaning the condenser, the acid apparently finding the weakest spots. The metallic packing was not affected at all.

In later cleanings, better circulation was obtained by using a small pump as well as by increasing the vents to 3-in. pipe approximately 18 ft. high. Cast-iron pipe instead of steel was later used for all piping necessary in the introduction and circulation of the acid solution.

Water boxes, water-box covers and all exposed iron work and as much as possible of the tube sheet should be painted with acid-resisting paint to safeguard against any possible action of the acid on them.

Results of Laboratory Analyses of Samples Taken from Surface Condenser During Cleaning

Actual amount of acid and water put in the condenser figured out to be 4.2 per cent acid and the sample taken immediately after it was all in the condenser showed 2.8 per cent, indicating that the action was extremely rapid.

Analyses of condenser tube deposit immediately before cleaning:

Silica	4.32 per cent
Iron oxide	89.00 per cent
Calcium sulphate	trace
Calcium carbonate	6.68 per cent

Analysis of solution 10 hr. before condenser was emptied:

Muriatic acid	none
Iron	1258 grains per gallon
Copper	none

Analysis of solution collected at drain from bottom of condenser when it was emptied:

Muriatic acid	none
Iron	1644 grains per gallon
Copper	none

Analysis of sludge in suspension in the solution drained from condenser on dry basis:

Silica	19.19 per cent
Iron oxide	30.38 per cent
Copper	none

(To be concluded)

Beryllium may soon be an important metal in industry. Up to 1922, it sold at $5000 a pound but by researches of Hugh S. Cooper, methods of production of beryl, a waste from feldspar mines, have been perfected so that it can be sold at $50 a pound and Mr. Cooper hopes that by 1931 the price can be reduced to $10 a pound.

Properties which make beryllium worth developing are: its light weight, only two-thirds that of aluminum; its hardness, such that it scratches glass easily; its expansion and contraction with temperature, almost the same as iron; resistance to tarnishing and capacity for high polish; high melting point, approaching that of steel.

In alloys it gives strength and resistance to corrosion to aluminum; hardness to iron, stiffness to copper. One interesting application is for emergency windows in X-ray tubes, where its lightness permits transmission of rays 17 times as well as aluminum, hitherto generally used.

Twenty days for delivery of two 813-hp. boilers ordinarily requiring from 45 to 60 days to deliver, was the record made in May by the Edge Moor Iron Co., Edge Moor, Delaware. The boilers were for the Rioco Refinery of the Richfield Oil Co., Los Angeles, California, and the reason was that the Edge Moor Iron Co. had already been at work on two boilers exactly as desired by the Richfield Oil Co., when the order was placed on April 16. The boilers were shipped from the Wilmington, Delaware, Marine Terminal May 6.

Design of Steam-Electric Generating Stations

FEATURES WHICH MUST BE CONSIDERED IN DESIGN OF MODERN POWER PLANT WITH PARTICULAR REFERENCE TO NEW STATION C AT OAKLAND. BY R. C. POWELL*

POWER PLANT DESIGNERS are today confronted with a large volume of ideas, practices and equipment. In order to arrive at the best solution for any particular case, it is necessary to carry through in considerable detail a number of studies, the object, of course, being to design a plant which will be safe and reliable in service and produce power at the lowest possible cost. Capital charges as well as the operating, maintenance and fuel costs must be considered.

Probably the factor of greatest importance is the size of the units. In general, it will be found best to use these as large as possible, as this will have a pronounced tendency toward lowering capital and operating costs and will work in well with present tendencies toward automatic control. This is particularly true in the boiler room, since the cost of such control is practically the same for a large as for a small unit, so for large boilers one can put in automatic combustion control, together with enough meters to delight the most ardent enthusiast for about $0.35 per kw.

PARTICULAR CONDITIONS DETERMINE SIZES

Sizes cannot be determined arbitrarily, as they will depend upon the size of the system, load conditions, ultimate size of plant where a new plant is contemplated or the space available if an existing plant is to be reconstructed. Figure 1 will give an idea of the relation between cost and size of generating units and show the advantage of using units of at least 30,000 kw. Sizes of the turbine and boiler units available may be the determining factor in choosing the steam pressure. As the pressure is increased from 750 lb. to say 1400 lb., the units offered by manufacturers become smaller, making necessary an economic compromise.

Existing installations using 1200 lb. nominal pressure, actually 1200 to 1400 lb., employ high pressure turbines which exhaust through a reheater into constant pressure headers to which are connected lower pressure turbines and boilers. Thus only a portion of the steam is generated at 1200 lb., the greater part being generated at 300 and 350 lb. A more economical arrangement, of course, is to generate all steam at 1200 lb., exhausting at varying pressure depending upon load.

Because of the high pressure it is necessary to hold down the diameter of the high pressure turbine shell and this is possible by going to 3600 r.p.m. This high speed immediately limits the size of such a high pressure turbine to about 15,000 kw. for a unity power factor unit. The largest 1200-lb. units now being built are 12,000 kw., making the total capacity of such a cross compound unit about 63,000 kw. Furthermore, 1200 lb. boiler units are limited as to steam output, making two boilers per turbine unit necessary. This, with the varying pressure, introduces complications in the reheating arrangement. For large stations, 1200 lb. pressure is an inherent economic handicap until larger units can be developed.

It is interesting to consider the gain in thermal efficiency where the pressure is increased, with a total steam temperature of 725 deg. F. assumed as the upper limit of conservative practice. With increasing pressure, it will be necessary at some point to introduce reheating in order to avoid reduction of turbine efficiency and perhaps excessive blade maintenance due to wet steam in the lower stages. At 1200-lb. throttle pressure, the steam at the exhaust without reheating would contain about 20 per cent moisture while at 425 lb. the exhaust contains 8 or 10 per cent moisture. With a reduction in machine or hydraulic efficiency of about one per cent for each per cent of moisture, it is easily seen that reheating is necessary for 1200 lb. It seems to be the general opinion that, for a total temperature of 725 deg. F., 425 lb. is the upper limit without reheating. The Rummelsburg (Klingenberg) Station in Berlin is operating without reheating at about 500 lb. pressure, 780 deg. F. This corresponds to about 425 lb. 725 deg. F., insofar as the effect of moisture on the turbine performance is concerned. The Langenburge Station is operating without reheat at about 750 lb. 840 deg. F., which likewise corresponds to about 425 lb. 725 deg. F. on the basis of turbine performance.

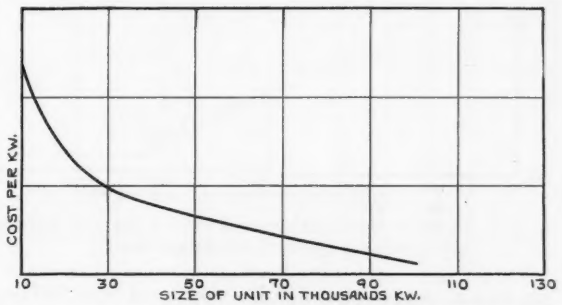


FIG. 1. COST OF GENERATING UNITS DECREASES AS THE SIZE IS INCREASED

RELATIONS BETWEEN HEAT CONSUMPTION AND PRESSURE

For the variation of heat consumption with pressure, 425 lb. will be taken as the lower limit of throttle pressure, since a number of studies by various engineers indicate that a plant for this pressure can be built for as low, if not lower, a cost per kw. capacity than at some lower pressure. This may appear anomalous to many. It is clear, however, that a compensating factor of considerable importance enters, due to improved efficiency and lowered water rates with higher pressure. The cost of turbines is not influenced a great deal by pressure up to 425 lb., but although boilers are more costly per unit of surface, less surface is required, smaller piping can be used. There is also a reduction in the size of auxiliaries, such as condensers, circulating water systems, pumps, fans and miscellaneous items.

*Pacific Gas & Electric Co., San Francisco, Calif. From a paper presented before the San Francisco Branch of the A. S. M. E.

In the following table the heat consumption based upon extraction cycle is given for different pressures. The unit is assumed to be 50,000-kw. capacity, allowance being made for steam pressure drops between the turbine shell and heater and for temperature drops between the extraction steam and the feedwater and the values are about what should be expected in practice. The study indicates that cross compound units for 1200 lb. pressure should prove as suitable for any type of load from an operating standpoint as a unit for lower pressures.

In general, the 1200 lb. pressure installation would cost more than one using 425 lb., although in certain instances where old plants are rebuilt the 1200 lb. unit may require less capital than the 425 lb. unit where the

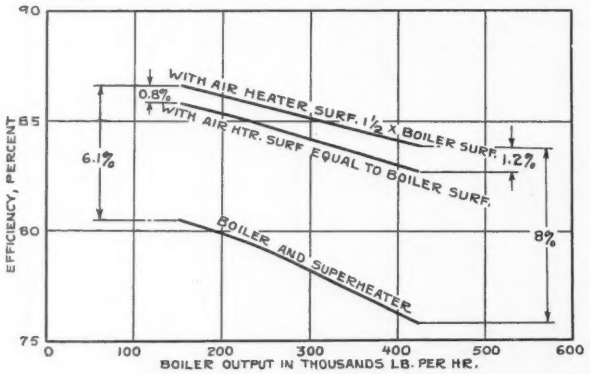


FIG. 2. CURVES SHOWING THE EFFECT OF AIR HEATER SURFACE ON BOILER EFFICIENCY

maximum plant capacity is considered and balanced against the cost and capacity of the new plant. For an example, if an existing turbine room is wide enough for a compound unit, more capacity can be installed in a given length than if single flow units are used. The available circulating water may then be an important item. With 1200 lb. pressure, only about 6.25 lb. of steam per kw-hr. are condensed, as against about 8.5 lb. for 425 lb. pressure. This means that with the same circulation water 35 per cent more capacity is possible at the higher pressures.

Effect of Increasing Pressure on the Thermal Economy of a Plant

Cycle	B.t.u. per kw-hr.	Per cent gain over 425 lb.
425 lb. 725 deg. F.	11,600	...
625 lb. 725 deg. F. with live steam reheating	10,400	10.4
625 lb. 725 deg. F. with boiler reheating to 725 deg. F.	10,110	12.9
1200 lb. 725 deg. F. with live steam reheating	9,680	16.6
1200 lb. 725 deg. F. with boiler reheating to 725 deg. F.	9,400	19.0

If the load factor or the price of fuel would justify the use of 1200 lb., varying loads would offer no disadvantage.

When a comparison is made between 1200 lb. and the lower pressure, say 425 lb., some consideration should be given to the lower obsolescence depreciation of the 1200 lb. installation. There appear to be sufficient theoretical and practical reasons to justify the conclusion that 1200 to 1500 lb. will probably remain the upper limit of pressures for some time, and that the next development will be toward higher temperatures. Such development is already well under way in Europe.

Rebuilding of Existing Plants Shows Possibilities of Lowering Power Costs

In revamping an old plant, the designer has limitations not imposed upon him in laying out a new plant. Notwithstanding such limitations, there are possibilities for low cost power by rebuilding existing plants. Station C of the Pacific Gas & Electric Co. consisted of two vertical turbines rated at 9000 and 12,000 kw. and a horizontal unit rated at 12,500 kw. Although it was necessary to remove a portion of the old boiler room building, the turbine room building was used with slight alterations. By extending the turbine room two bays and departing somewhat from the conventional type of turbine, two turbines rated at 37,500 kw. each and having a maximum output of 42,000 kw. can be installed by removal of the two vertical units. Only the 9000-kw. unit was removed to make room for the first new unit.

On account of the space limitation and load conditions, a reheating cycle was neither possible nor desirable and a boiler pressure of 450 lb. was chosen as the

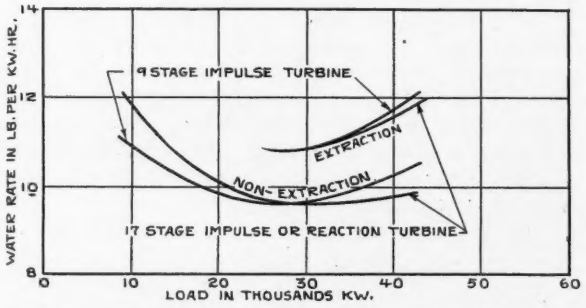


FIG. 3. COMPARISON OF TWO DIFFERENT TYPES OF TURBINES FOR EXTRACTION AND NON-EXTRACTION

upper limit with a maximum final temperature of 730 deg. F. Large boiler units were selected as being the most economical, although smaller boilers could have been used as far as steam output was concerned. Two Babcock & Wilcox 35,462-sq. ft. cross drum boilers, the largest of this type built to date, were selected, one of them to serve as a spare. They have 60-in. drums and 24 ft. tubes arranged 51 tubes wide and 24 tubes high.

Because of the high feedwater temperature leaving the heaters, space arrangement and to avoid complications, it was considered desirable to omit economizers and to raise the efficiency at the higher loads with air heaters. With an air heater surface of 52,000 sq. ft. a guaranteed efficiency of 84 per cent for an output of 425,000 lb. of steam per hour was obtained, but in order to hold down the air temperature to about 500 deg., some additional boiler surface was required. This, how-

ever, did not add greatly to the cost. The air heater surface may appear somewhat excessive, being 140 per cent of that of the boilers. With the type of heaters used, however, the cost of this surface as against one equal to the boiler surface was about $0.25 per kw. of capacity. With the larger air heater an improvement in overall plant efficiency was brought up, at full load, to equal that of a plant using a conventional turbine unit with air preheater surface equal to that of the boiler.

At loads below 28,000 kw., the Station C layout is much more efficient than usual practice. Figure 2 gives curves showing the effect of air heater surface on the combined boiler unit efficiency. The improvement in efficiency increases with boiler output and this is a desirable feature for operating as standby where loads are to be picked up quickly. At Station C the turbine output can be increased from standby minimum to full load in an extremely short interval of time.

Curves in Fig. 3 show the water rate for a 9 stage Station C turbine in comparison with those of the usual type, for both non-extraction and extraction with four heaters. The use of four heaters raises the temperature of the feedwater to 370 deg. and brings the efficiency of the nine stage unit to within about 1 per cent of that of the ordinary unit. By this development about $1.50 per kw. is saved in building foundation and turbine cost.

Power Supply for Auxiliaries

Direct current supply will give the most flexible and best feed control, but is out of the question on account of the difficulty of furnishing such a supply. There are three methods for obtaining alternating auxiliary supply: take from the main bus; auxiliary generator direct connected to the main unit; and a separately steam driven auxiliary generator, the so-called house type. The cost of an auxiliary generator driven by the main turbine is not justified for the small measure of additional security for large transmission systems due to the liability of the main turbine to trip out at overspeed. For about the same cost, an arrangement of main bus supply with emergency house generator is better, since this will assure an auxiliary supply under all conditions. With this scheme, the house generator which is driven by a turbine exhausts to atmosphere and is automatically put on the auxiliary supply in the event of trouble. The main bus ties are at the same time automatically disconnected.

At Station C, the auxiliary supply is taken from the main 11 kw. buses and stepped down to 2300 and 230 v. Automatic throw-over switches will insure auxiliary supply excepting in the event that both 11 kw. main station buses are out. Direct current is used for the auxiliary combustion control and power for the motor operated valves and is furnished by a 25-kw. dual drive set. The boilers are fired automatically by the Bailey combustion control and all auxiliaries are automatically controlled. In the event of failure of auxiliary power, all auxiliaries start automatically and come up to the proper speed upon restoration of the supply. Condensate and boiler feed pumps are driven by slip ring variable speed motors. The condensate pump motors are controlled by a float connected with the condenser and a constant pressure of 550 lb. is automatically maintained at the feed water header.

Because of the large size and output of the boilers and the rather high draft required, the fan problem was troublesome. It was finally decided to use only one forced and one induced draft fan per hour and to depend upon somewhat heavier than usual fan construction to insure greater reliability. Each forced draft fan is driven by one 400 and one 150-hp. standard squirrel cage induction motor, and each induced draft fan by one 400 and one 210-hp. motor of the same type.

Motors are full voltage starting, thus avoiding the expense and complication of starting equipment. It may be interesting to mention, in connection with the across-the-line starting of large motors, that one of the motors driving a circulating water pump is a 500-hp.

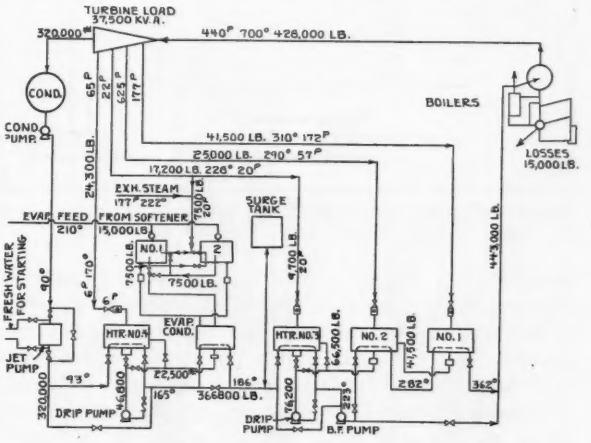


FIG. 4. HEAT BALANCE DIAGRAM FOR UNIT NO. 1, STATION C, AT OAKLAND, CALIF.

synchronous motor and is started in the same manner without the use of starting equipment other than minor control equipment for automatically controlling the d.c. field. The advantage of this type of motor over the induction motor is lower first cost for the low speeds required, unity power factor and a higher efficiency which, for this particular motor, is 94 per cent.

Condensers are of the single pass type with 28,000 sq. ft. or about ⅔ sq. ft. per kw. About 60,000 g.p.m. of 70 deg. water, or about 1.5 g.p.m. per kw. will be supplied. Four extraction feedwater heaters are used to heat the feedwater up to about 370 deg. F. at maximum turbine output. This is within about 90 deg. of the saturated steam temperature at 450 lb. The heat balance diagram is shown in Fig. 4. Evaporators are supplied with water at 210 deg. F. from a hot lime and soda softener.

On this station, an attempt was made to build, at low first cost, a plant which would prove economical in operation, maintenance and fuel consumption. It is anticipated that the overall cost per kw. for installing the units will not exceed $65 and that the fuel consumption will be in the order of 14,500 B.t.u. per kw-hr. at full load, or about 430 kw-hr. per bbl. of oil. With the large boiler units and complete automatic control the operating cost should be low.

Steam Generation at Critical Condition[1]

RECENT INSTALLATION AT CABLE WORKS OF SIEMENS-SCHUCKERTWERKE A. G. DEMONSTRATES POSSIBILITIES OF THE PROCESS

AFTER THE ORIGINAL Benson process experiments in England and further development in an experimental boiler in the power plant of the Siemens-Schuckertwerke A. G., it was decided to use this new process in an extension of the boiler plant of the Gartenfeld Cable Works of the same company for the purpose of supplying steam for the generation of power, indus-

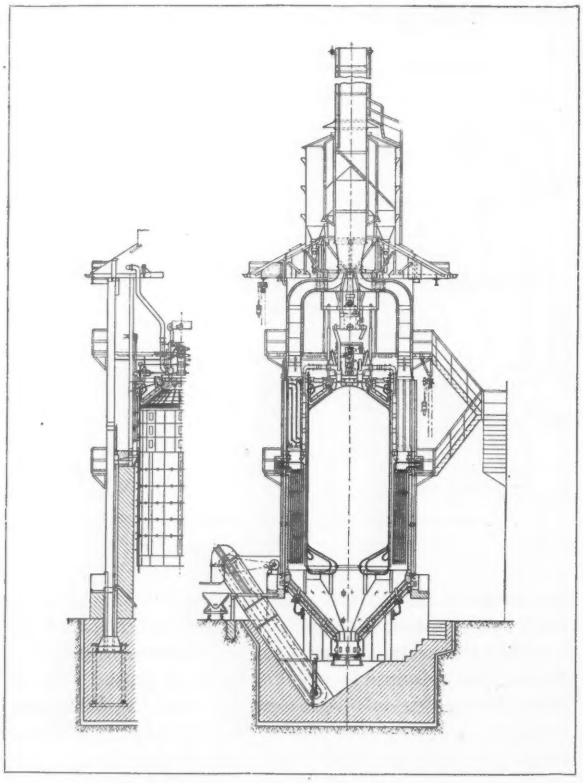


FIG. 1. SECTION OF THE BENSON BOILER SHOWING DETAILS OF CONSTRUCTION

trial process and heating. In the experimental plant,[2] designed for about 22,000 lb. of steam per hour, a converted Borsig boiler was used. Steam generation takes place at the critical pressure and is throttled to about 1400 lb. per sq. in. before reaching the turbine. The new boiler shown in the photograph, on the contents page and in the cross section, Fig. 1, has a normal capacity of about 55,000 lb. of steam per hour. Steam generation takes place at the critical pressure, as in the older boiler, but is throttled to about 2550 per sq. in. for use in the turbine.

Steam generation in the Benson process takes place at the critical condition (3300 lb. per sq. in. in 705 deg. F.) where the specific volume of saturated steam equals that of water and the latent heat of vaporization is zero. Under these conditions, there is no steam and water mixture so that boiler drums for the separation of steam and return tubes for water circulation are unnecessary. Steam generation takes place according to the simple diagram shown in Fig. 2.

Feedwater is fed into the system at 3400 lb. pressure by means of a high pressure pump (a). It is first heated to the critical temperature to form saturated steam, which is later superheated by the addition of more heat. This superheated steam is delivered to the prime mover (d) and upon condensing returns to the

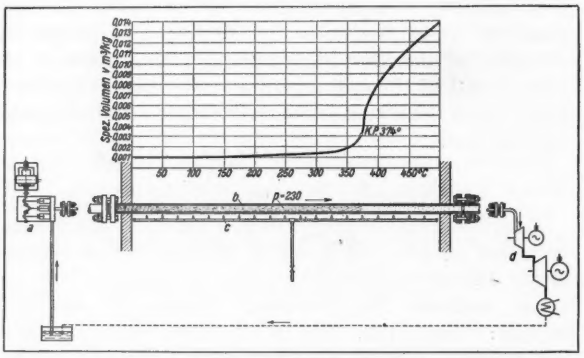


FIG. 2. A SIMPLE DIAGRAMMATIC REPRESENTATION OF THE BENSON PROCESS

hotwell from which the boiler feed pump takes its suction.

When steam is generated under these conditions, without water circulation or boiler drums, a uniform distribution of heat to and water through the tubes is necessary. For this reason, the cylindrical furnace shape, shown in Fig. 1, was adopted. Furnace walls are made up of closely faced bare metal tubes looped at the lower end to form an ashpit screen. Some of them on the return bend are carried over at the top to cool the parabolic ignition arch.

A funnel shaped ashpit, terminating in a quenching pit, is provided. After quenching ash and clinkers are lifted from the pit to an industrial car by means of a motor driven elevator. Gases of combustion pass downward through the ashpit screen and then upward through eight superheater elements and eight preheaters to the propeller type induced draft fan, from which they are discharged through a dust chamber to the stack.

Feedwater is supplied through a distribution header located above and on the central axis of the combustion chamber. From here it is supplied to the tube elements which form the furnace walls, where the water is heated, saturated steam is formed and some superheat takes place. The superheated steam returns to a second

[1] From an article, translated by John H. D. Blanke, appearing in Siemens-Zeitschrift by H. Gleichmann, Department of Central Stations of the Siemens-Schuckertwerke, A. G., Berlin.

[2] Described with operating data, Power Plant Engineering, July 1, 1927, page 740.

header which supplies four of the superheater chambers located in the second pass. The remaining four superheater sections are used to reheat, at 525 lb., some of the exhaust steam from the high pressure section of the turbine.

Air Preheaters Placed Above Superheater Elements

Air for combustion is taken into the boiler through openings in the foundation, and from there passes up through the hollow cover of the eight superheater chambers and eight air heaters, down through the preheater, countercurrent to the flow of gases, into a circular manifold located behind the combustion chamber tubes and formed by the cast-iron casing. A small part of this air is used for primary air to the burners located in the roof.

Secondary air is supplied by eight rows of secondary air nozzles, so placed that air is blown in for about ⅓ of the height of the combustion chamber. The width of the slots or nozzles decreases from the top toward the bottom and they are placed tangential to an imaginary circle for the purpose of giving the necessary turbulence in the furnace.

Eight burners located at the top and arranged concentrically around the central axis of the boiler, as shown in Fig. 3, are provided. Four of these are for pulverized coal, and four are oil burners used for starting. Coal is pulverized in a roller mill and dried by direct contact with flue gases, the gases and moisture being bled from the system through cyclones and electrostatic precipitators. Pulverized coal bunkers are located directly below the cyclones and the pulverized coal is fed from them direct to a distributor supplying the four burners.

Since little attention is required for the boiler and the construction is such as to form a closed tower, a boiler house is superflous and the boiler appears as an isolated structure as shown on the contents page. The plant is controlled either automatically or by push buttons, from a control room located some distance away in the machine shop. Pyrometers are installed for each of the eight tube elements, and an increase in temperature is an indication that the soot blowers should be operated. It is stated that scale does not form in the tubes because, operating at critical pressure, no formation of steam bubbles takes place in the tubes, therefore scale is not deposited on the metal.

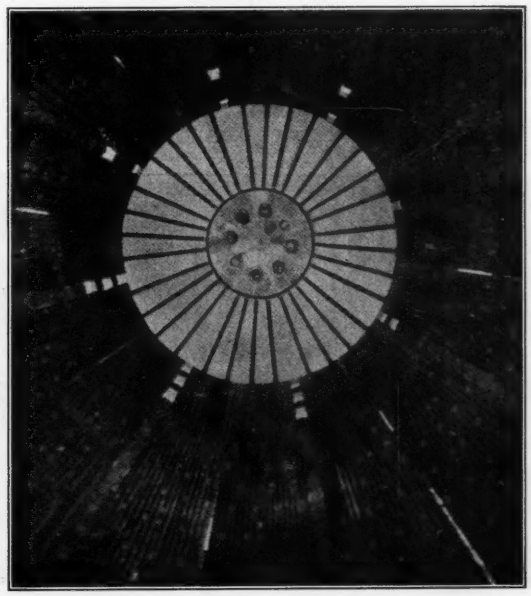


FIG. 3. VIEW LOOKING UP INTO THE COMBUSTION CHAMBER

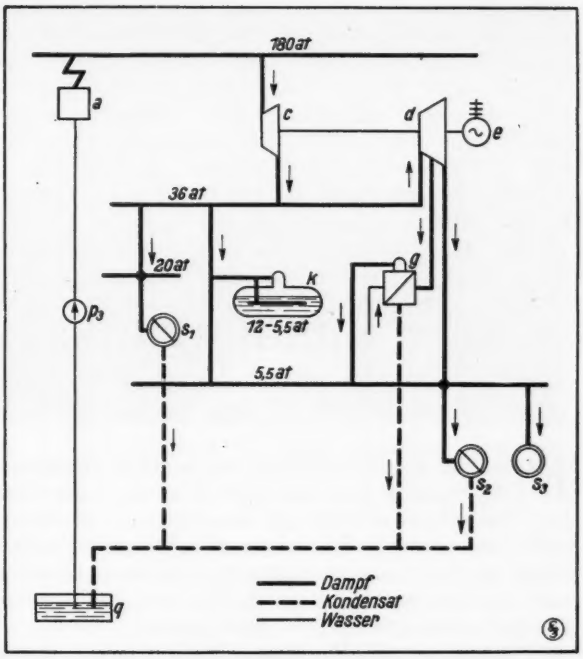


FIG. 4. DIAGRAMMATIC REPRESENTATION OF THE FLOW DIAGRAM AT THE GARTENFELD CABLE WORKS

Fundamentally, the flow system of the Cable Works plant is shown by the diagram, Fig. 4. Steam generated in the boiler (a) is delivered to the high-pressure section of the turbine at 2550 lb. pressure, to be expanded to 525 lb. Part of the discharge of the high-pressure turbine is reheated and passed to the low-pressure element (b), while part of it is used for process work in S_1. Any possible excess steam is stored in the Ruths accumulator (k).

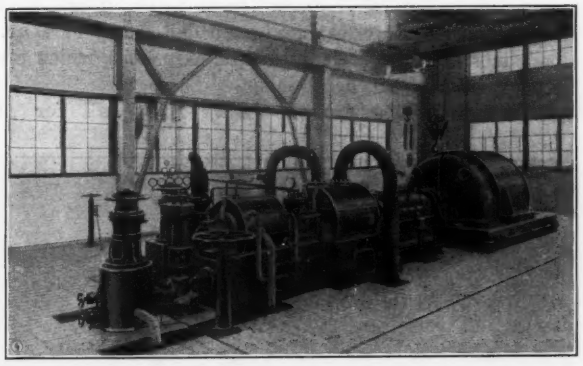


FIG. 5. VIEW OF THE TURBINE ROOM WITH THE HIGH-PRESSURE SECTION OF TURBINE IN FOREGROUND[3]

Exhaust from the low-pressure element, at 80 lb.,

[3] Cross section of turbine shown in Power Plant Engineering, February 1, 1928, page 178.

is used for process work in S_2 and S_3. Condensate from S_3 is contaminated with acid and cannot be returned, so that the makeup must be supplied to the system from the evaporator (g) operated on steam bled from the low pressure element of the turbine. Drains from the process equipment and evaporator return to the hotwell (q), from which the boiler feed pumps take their suction. A photograph of the turbine is shown in Fig. 5.

Heat requirements of the cable works were such that design problems were difficult. The largest part of the steam is required at 80 lb. 465 deg. F., with a somewhat smaller demand for steam at 295 lb. 465 deg. F. The steam delivery from the boiler plant for process work must be maintained at the same temperature and pressure even though the turbines are shut down. Because of this, the actual plant design is intricate, requiring a great deal of apparatus which is not concerned with the Benson process proper and is not required with a normal power plant.

Handling and Burning Iowa Coal

New University of Iowa Power Plant, Designed for Midwestern Coal, Has Unique Features

FOR THE PAST few years, the problem of successfully burning Iowa and other Midwestern coals has been the subject of thorough investigation and experiment and the new University of Iowa power plant, shown in Fig. 1, has incorporated in its boiler room design all the desirable features of stoker and furnace design brought out by past developments.

Four 612-hp., 175 lb. pressure Stirling boilers, shown in Fig. 2, are at present installed and in use. They are equipped with natural draft Greene chain grate stokers and Detrick concave-convex combustion arches installed as shown in the cross section of the furnace and stoker arrangement, Fig. 3. Each boiler has a Foster convection type superheater and Diamond soot blowers. Iowa coal was used almost exclusively the first four months the plant was in operation and boiler rating of 150 per cent with this coal has been secured without difficulty. Using Illinois coal, ratings of from 200 to 250 per cent can be obtained.

Ash is discharged from the back end of the chain grates, quenched by a water spray and stored in Beaumont suspended ash hoppers, from which it is drawn off, once each shift, in hand-propelled dump cars and loaded into a Link-Belt automatic skip hoist which elevates it into a 50-ft. ash bunker.

Ultimate plans for the boiler room call for an H-shaped building with four boiler room units, of four boilers each, with the coal and ash handling unit forming the cross bar. The two newest units of the boiler room have been built, four boilers are already in place and four more will soon be installed. Each unit of the four boilers will have its own 210 ft., 9 ft. 6 in.-diameter, reenforced concrete stack.

Coal is carried from a track hopper by means of a 30-in. Link-Belt apron conveyor and discharged to an 18 by 15-in. pivoted bucket conveyor which elevates it into one of the two 300-t. bunkers. In the bottom of the bunkers are gates which discharge into the hopper of a motor-driven 1-t. weigh larry which travels down the center of the firing aisle and empties into the stoker hoppers.

In the north end of the boiler room is a Cochrane 200-gal. per hr. combined hot process water softener, storage tank and open heater, and three Allis-Chalmers boiler feed pumps, two turbine driven and one motor driven. On the west side of the boiler room, beneath the back end of the boilers is the water supply reservoir of the university which at 22.5 ft. depth has a capacity of 225,000 gal. Highly sulphated water pumped from deepwells with an air lift is stored in this reservoir until it loses the sulphur odor and taste. It is then pumped into the mains for general service.

Electric power will be generated by two 1000-kw., 2300-v., 2-phase, 60-cycle Westinghouse bleeder type

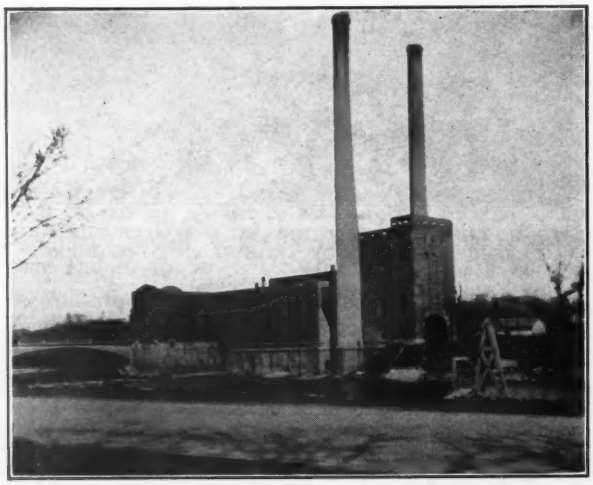


FIG. 1. EXTERIOR VIEW OF THE NEW UNIVERSITY OF IOWA POWER PLANT

FIG. 2. FOUR BOILERS OF THE FIRST UNIT ARE SERVED FROM THE CENTRAL BUNKERS BY A WEIGH LARRY

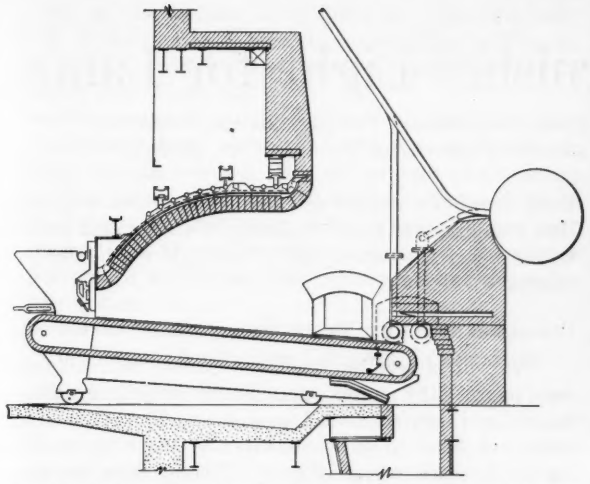


FIG. 3. CROSS SECTION OF THE FURNACE SHOWING THE ARCH AND STOKER ARRANGEMENT

FIG. 5. TWO 1000-KW. BLEEDER TURBINE UNITS OPERATE IN PARALLEL WITH A 156-KW. HYDRO-ELECTRIC UNIT

units with 18-kw. direct connected exciters. These turbines are shown in Fig. 5. Each turbine will be installed over a 1000-sq. ft. Westinghouse surface condenser with two-stage steam jet vacuum pumps equipped with inter and after coolers which drain through Fisher traps to the condenser hotwells. These two generators will operate in parallel with an S. Morgan Smith 156-kw. 90-r.p.m. water wheel driving an Electric Machinery Mfg. Co. generator.

The university owns the dam and power rights on the river at this point and the new power plant is located at one end of the dam and the new hydraulic laboratory at the other. When complete and in full operation, the plant, costing well over $800,000, will supply the heating and power loads of both the East and West Campus of the university. Steam lines for the former are carried under the river through a tunnel in the dam and to the latter by a 1600-ft. reenforced concrete walking tunnel 7 ft. high and 5 ft. wide. Proudfoot, Ross and Powers were architects for the superstructure while Professor B. P. Fleming of the mechanical engineering department of the university has had complete charge of the entire project, including investigations, general and detailed design of the building, equipment, tunnel structure, supervision and erection of equipment.

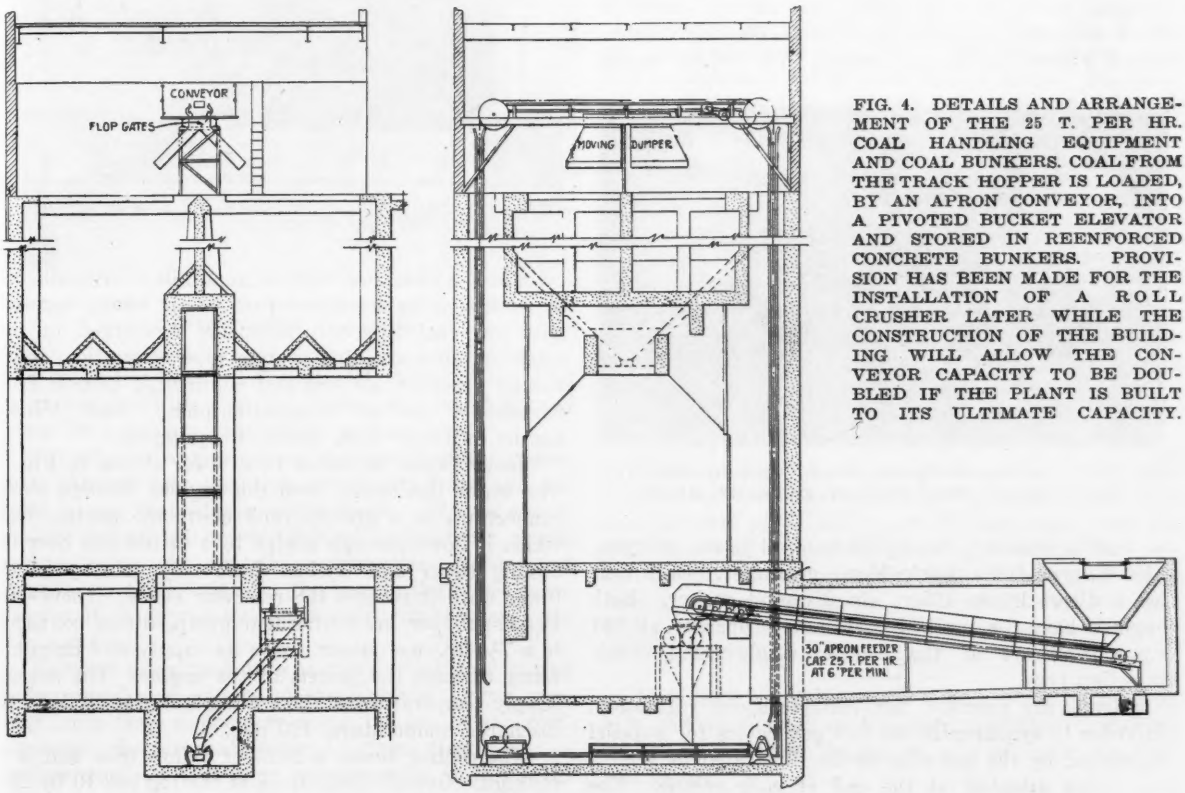


FIG. 4. DETAILS AND ARRANGEMENT OF THE 25 T. PER HR. COAL HANDLING EQUIPMENT AND COAL BUNKERS. COAL FROM THE TRACK HOPPER IS LOADED, BY AN APRON CONVEYOR, INTO A PIVOTED BUCKET ELEVATOR AND STORED IN REENFORCED CONCRETE BUNKERS. PROVISION HAS BEEN MADE FOR THE INSTALLATION OF A ROLL CRUSHER LATER WHILE THE CONSTRUCTION OF THE BUILDING WILL ALLOW THE CONVEYOR CAPACITY TO BE DOUBLED IF THE PLANT IS BUILT TO ITS ULTIMATE CAPACITY.

Diesel Engine Plant Furnishes Light for Lamar

City of Lamar, Mo., Establishes Lighting Plant Containing Two Generating Units, Which Furnish Power and Light for Commercial Purposes as Well as City Service

MANY more or less isolated cities are availing themselves of the reliability and economy of operation which are features of the modern large Diesel engine.

Among the recently built municipal Diesel engine power plants, the one at Lamar, Fig. 1, which went into operation on February 3, illustrates what may be done by small isolated communities. This plant supplies

FIG. 1. ATTRACTIVE BUILDING HOUSES LAMAR'S POWER APPARATUS

electric power and light to commercial interests in Lamar as well as serving the city. The building is of tile, well lighted both naturally and electrically, and has attractive surroundings.

Two units, one a 240-hp., 4-cylinder Fairbanks-Morse Diesel engine, the other a 360-hp., 6-cylinder engine of the same make were installed. The 240-hp. engine is direct connected to a 200-kv.a., 3-phase, 60-cycle, 2400-v., type D Fairbanks-Morse generator. The 360-hp. engine

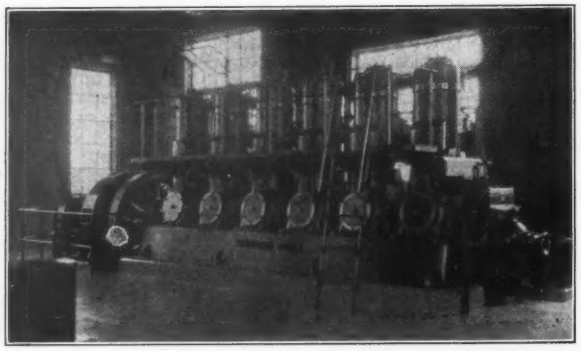


FIG. 2. F. M. 360-HP. DIESEL ENGINE SHOWING SYNCHRONIZING APPARATUS AT EXTREME RIGHT

is direct connected to a 300-kv.a., 3-phase, 60-cycle, 2400-v., type D Fairbanks-Morse generator. Each unit has a direct-driven 125-v., shunt-wound exciter. Both engines have 14 by 17-in. cylinders, operate at 257 r.p.m. and are of the 2-cycle, single-acting, solid-injection type.

Means are provided for variable speed regulation, in order to synchronize the two generators for parallel operation, by the use of a device illustrated in Fig. 3, one being attached at the end of each engine. The hand wheel changes the setting of the governor springs, thus changing the time of closing of the suction control valves, hence the amount of oil fuel injected by the fuel pumps.

Submerging of Fuel Pumps Establishes Perfect Seal

Fuel oil is received on the adjacent railroad track and pumped by means of a Blackmere rotary pump, which is direct connected to a 3-hp., Fairbanks-Morse motor, to the storage tanks shown at the extreme right in the background in Fig. 1. These tanks serve by gravity two 300-gal. supply tanks, located in an oil supply pit P, whence it is drawn by the engine to an auxiliary reservoir which is located on a deck near the

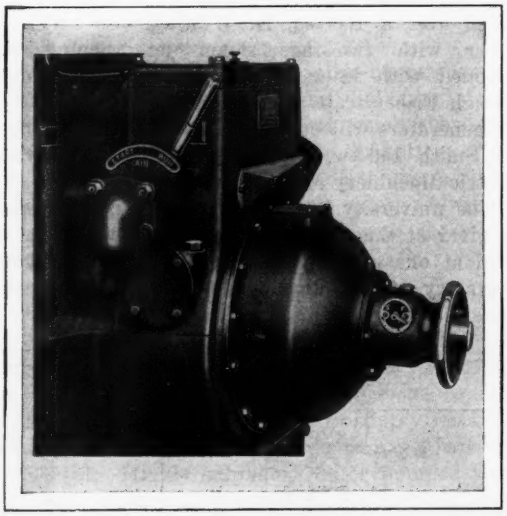


FIG. 3. SPEED REGULATOR SHOWING HANDWHEEL FOR ADJUSTMENTS AND INDICATING DIAL

cylinders. This reservoir is kept filled with oil fuel by means of an auxiliary fuel pump which, together with the fuel injection pump, is submerged in this reservoir, thus avoiding suction pipe connection, establishing a perfect air seal and eliminating trouble from variation of head on the injection pump. Each cylinder has its own individual injection equipment.

Jacket water is cooled in a tower shown in Fig. 1. The water discharges from the engines through closed connections to a gravity tank above the engine, from which it flows through a pipe to a distributor over the cooling tower and trickles from tray to tray in the tower until it reaches the reservoir below. Thence the 12,000-gal. per hr. centrifugal pump, direct connected to a 7½-hp., a.c. motor draws its supply and circulates water through the jackets of the engine. The average supply temperature of the cooling water is 60 deg.; the discharge temperature, 120 deg.

The cooling tower is built of yellow pine and is 22 ft. high. Overall dimensions at the top are 10 by 28½

ft. and at the bottom, 12 by 30½ ft. The reservoir, which is of reinforced concrete construction is 30½ ft. long by 12 ft. wide with an average depth of 5 ft. Its capacity is 12,910.5 gal.

Arrangement is provided by which the water may be discharged from the engines direct to the reservoir during freezing weather. For the purpose of providing an escape for steam or air that might collect and interfere with proper circulation of the cooling water, a riser is connected to the water outlet pipe, close to the engine and extended 10 ft. above the highest level of the water in the system.

Continuous Filtration Improves Lubrication

Lubrication is entirely automatic. The main bearings are ring-oiling; the crankpin bearings, pistons and piston pins are supplied with oil by a mechanical force feed lubricator and the governor and related parts are supplied by splash lubrication in the governor housing as shown in Fig. 4. Used lubricant, from the base of the engine, passes to the sump at the bottom and is continuously filtered. A pipe connected to the engine cooling water overflow, supplies hot water to the jacket to keep the oil warm. Lubricating oil is stored in tanks

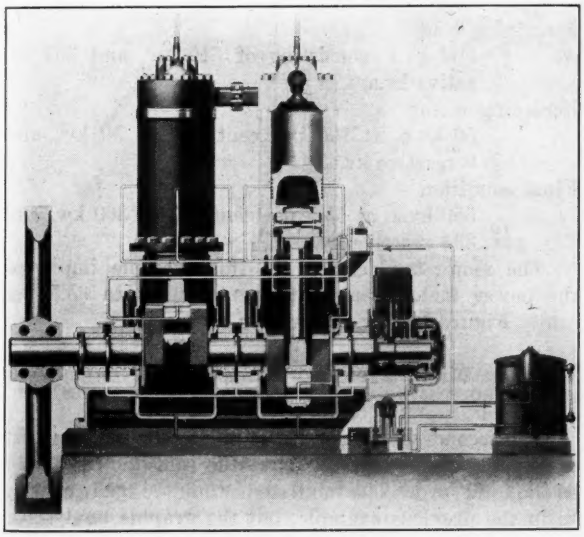


FIG. 4. LUBRICATION IS AUTOMATIC AND LUBRICANT CONTINUOUSLY FILTERED

in a small tile house at the rear of the main building as shown at H in Fig. 1. Later, this building will house the heating plant for the engine room.

Air supply for combustion is drawn from the engine room through two openings, one in the front and the other in the rear of the engine bases. The air passes through cylindrical screens located in the bases, which assures clean air for the combustible charge and through air check valves in the base to the crank cases, whence it is forced by crank case compression, into the cylinders.

Exhaust gases pass into mufflers which are located underground just outside of the building. Pipes running from these mufflers to above the hip of the roof, discharge the exhaust without other treatment, as further elimination of noise is unnecessary in this plant due to its location well away from any residence section. Each engine has an individual muffler as indicated in Fig. 1.

Only Two Persons Required to Operate Plant

Electricity is generated and carried to the bus bars at 2400 volts. For the plant, it is transformed to 110 and 220 volts. The switchboard and its relation to the two engines is shown in Fig. 5. The peak load on the plant is now about 225 kw., the minimum load about 35 kw. and the average load 85 kw. The plant factor, or ratio of the average load to the rated capacity of the plant, is therefore, 85 divided by 500, or 0.17. The machine factor for each engine, or the average load

FIG. 5. VIEW OF PLANT SHOWING REAR OF 240-HP. ENGINE, SWITCHBOARD AND AIR STARTING TANKS

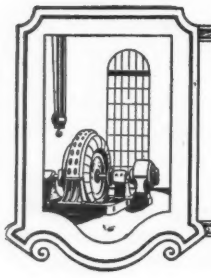
divided by the rated load, is 0.42 for the 240-hp. engine and 0.28 for the 360-hp. unit. This plant is operated by a chief engineer and one assistant who work 12-hr. shifts.

Receivers for starting air are shown in Fig. 5, the air being stored by means of a Fairbanks-Morse, type E air compressor belted to an electric motor. The pressure usually used for starting the engine when cold is about 225 lb.

According to the latest weekly report from Department of Commerce, Bureau of Mines, the total production of soft coal during the week ended June 2, including lignite and coal coked at the mines, is estimated at 7,382,000 net tons. Compared with the output in the preceding week, this shows a decrease of 992,000 t., or 11.8 per cent. The decrease was due almost entirely to the observance of Memorial Day which, over the fields as a whole, was equivalent to only four-tenths of a full working day and the daily average rate of output was but 2.1 per cent lower than in the week of May 26.

Total production of anthracite during the week ended June 2 is estimated at 1,494,000 net tons. This is a decrease of 533,000 t., or 26.3 per cent, from the high record of the preceding week. Memorial Day is a full holiday in the anthracite field. The average daily rate of output during the five working days was but 11.5 per cent less than that for the six days in the week of May 26.

Man is like a tack—useful if he has a good head on him and is pointed in the right direction; but even though he is driven, he can go only as far as his head will let him.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Reactive Component in A. C. Circuits

PART VI. FURTHER EXAMPLES, SHOWING THE METHOD OF DETERMINING CORRECTIVE CAPACITY. BY V. E. JOHNSON

IN OUR PREVIOUS discussion* of methods for determining corrective capacity in power factor problems, we presented a number of cases in which the corrective effect of an *added* load was the governing feature. As pointed out in that article, however, it is common practice to replace present motors of low power factor with motors of unity power factor, leaving the total power load the same. This is a special case of the general problem and its solution may be arrived at in two ways. These two methods will now be discussed.

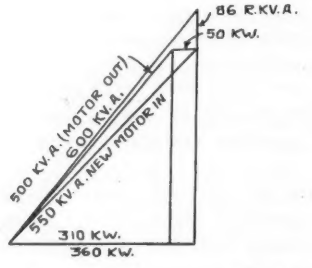


FIG. 1. VECTOR DIAGRAM OF A PROBLEM IN WHICH 100 KV.A., 50 PER CENT POWER FACTOR OF A 600-KV.A. LOAD WAS REPLACED BY A 100 PER CENT POWER FACTOR LOAD

Preceding examples have dealt with problems in which the corrective effect of added load has been the governing feature. It is, however, common practice to replace present motors of low power factor with unity power factor or synchronous motors, leaving the total power load the same. This, then, is a special case of the general problem and its solution may be arrived at in two ways.

First Method of Solution

The more accurate and, at the same time, more logical method of approaching the solution of this problem, is to deal with it on the basis of the actual motors that are to be replaced, calculating first the power factor which results from their elimination and then that following the replacement.

Example: Assume a load of 600 kv.a. at 60 per cent power factor, of which 100 kv.a. at 50 per cent power factor is to be replaced by a synchronous motor at 100 per cent power factor. Determine final power factor.

Solution: Resolve the various loads into their components and tabulate as follows:

Present load
600 kv.a. at 60 per cent p.f. = 360 kw. and 480 reactive kv.a.

Motor load to be replaced
100 kv.a. at 50 per cent p.f. = 50 kw. and 86 reactive kv.a.

Remaining load
500 kv.a. consisting of 310 kw. and 394 reactive kv.a.

Replacing motor
50 kv.a. at 100 per cent p.f. = 50 kw. and 0 reactive kv.a.

Final condition
550 kv.a. at 65.5 per cent p.f. = 360 kw. and 394 reactive kv.a.

The motor replacement in this example improved the power factor somewhat, increasing it to 65.5 per cent. Figure 1 shows the vector relations.

Solution When Replaced Motors Have Same Power Factor as Total Load

The second solution is based on the assumption that the motors to be replaced have the same power factor as the total load. The tabulation would be made exactly as in the previous example, but the graphic analysis is somewhat simpler. Using the values assumed, the diagram would be made as in Fig. 2. The original load is represented by the triangle OFB. The load to be replaced is laid off to scale at AB, leaving the load triangle OAC, to which is added the corrective capacity CDE, forming a final load ODB having a power factor of OB ÷ OD. Had the replacing motor had unity power factor, the final load would have been OHB. If, on the other hand, its power factor had been lagging instead of leading, the final load would have been OGB.

The location of the corrective triangle may seem to be somewhat confusing, but if it be always assumed that lagging reactive kv.a. are measured *upwards*, as from B to F, it will be seen that CDE and CHG fall naturally into place. CE, representing leading kv.a. is measured downward so as to reduce AC and AE, while HG, representing lagging kv.a. is measured upward, so as to lengthen BH to BG.

Solution of the power factor problem on a given installation or system, frequently involves the use of

*Part V, page 674, June 15 issue.

several of the general principles and may necessitate the re-arrangement of present motors (including the substitution of synchronous or self exciting induction motors on suitable drives) as well as the addition of corrective equipment. The following is a fairly typical example:

Problems Involving More Complex Solutions

Assume a load of 1000 hp. driven by a number of induction motors having a total capacity of 2000 hp. With sizes from 10 to 50 hp. and speeds of from 900 to 1800 r.p.m. (synchronous), the power factor will be about 75 per cent.

Neglecting losses, and omitting fractions in the results, the total input will be

$$\frac{1000 \text{ hp.} \times 746}{1000 \times 0.75} = 1000 \text{ kv.a. (approximately) or } 750 \text{ kw.}$$

Figure 3 is the load triangle under these conditions.

By using group drive on a number of machines, and by otherwise re-arranging the motors, it will be possible

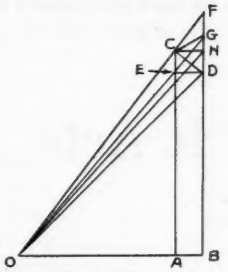


FIG. 2

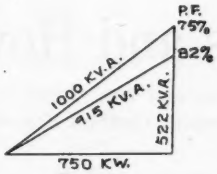


FIG. 3

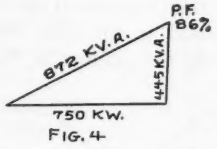


FIG. 4

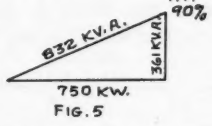


FIG. 5

FIGS. 2—5. VECTOR RELATIONS OF PROBLEMS INVOLVING MORE COMPLEX SOLUTIONS THAN THOSE GIVEN PREVIOUSLY

to remove 665 hp. leaving 1335 hp. operating at an average load of 75 per cent and having a power factor of 82 per cent. This gives the load triangle shown in Fig. 3, indicating a saving of 85 kv.a. total.

The nature of the load makes it possible to substitute a 150-hp., 100 per cent p.f. synchronous motor for four 50-hp. induction motors operating under the assumed average conditions. These four motors represent an input of 136 kv.a. with wattless and power components of 77 kv.a. and 112 kw., respectively. The synchronous motor at unity power factor entirely eliminates the 77 kv.a. wattless, leaving a load diagram as in Fig. 4. Up to this point, there has been a saving of 128 kv.a. while the power factor has been increased from 75 per cent to 86 per cent. This improvement would have been sufficient to avoid the penalty of an "80 per cent power factor clause" if the power rates had included one.

Further improvement would be possible by using a 150-hp. synchronous motor rated at 80 per cent leading power factor. Neglecting losses, such a motor would have a rating of 140 kv.a. and a reactive component of 84 kv.a. leading. The resulting load triangle would be that in Fig. 5, with a final power factor of 90 per cent. It would require 361 reactive kv.a. leading to raise this to unity.

Taking Account of Motor Losses

In the preceding example, motor losses have been neglected. In a rigid calculation, these would have to be included and the solution correspondingly modified. The various steps are here repeated, using assumed efficiencies at the different loads.

The half and three-quarter load efficiencies of the induction motors under consideration may be taken as 85 per cent and 90 per cent respectively. The original installation, totaling 1000 hp. output, would have an input of

$$\frac{1000 \text{ hp.} \times 746}{1000 \times .85 \times .75} = 1170 \text{ kv.a. or } 880 \text{ kw. and } 775 \text{ reactive kv.a.}$$

The load triangle is shown in Fig. 6.

After the re-arrangement of the motors, the output of 1000 hp. was handled by motors at 90 per cent efficiency and a power factor of 82 per cent, making a total kv.a. of 1010 and reactive and power components of 575 kv.a. and 830 kw. respectively. This is shown in Fig. 7.

The 150-hp. synchronous motor at unity power factor has an efficiency of 90 per cent, so that substituting it for the four 50-hp. induction motors, leaves the total power component 830 kw. These four motors at the assumed load, efficiency and power factor have an

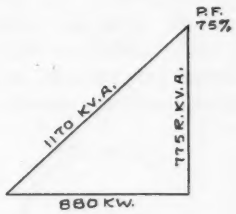


FIG. 6

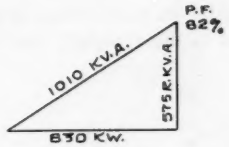


FIG. 7

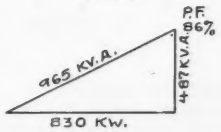


FIG. 8

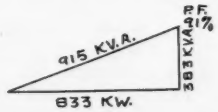


FIG. 9

FIGS. 6—9. VECTOR RELATIONS OF PROBLEMS TAKING INTO ACCOUNT THE EFFECT OF MOTOR LOSSES

input of 152 total kv.a., 124 kw. and 88 reactive kv.a. The reactive component is eliminated by the use of the unity power factor motor, so that the final load triangle becomes that in Fig. 8. Up to this point there has been a saving of 205 kv.a. and 50 kw., while the power factor has been raised from 75 per cent to 86 per cent.

The 80 per cent leading power factor motor has slightly lower efficiency, 88.5 per cent, and accordingly has an input of 158 total kv.a., 127 kw. and 94 reactive kv.a. leading. The total kilowatt input is therefore increased to 833, while the reactive component is reduced to $487 - 94 = 393$ kv.a.

The power factor becomes 91 per cent, with a total kv.a. of 915, as shown in Fig. 9.

It must not be assumed that the foregoing solutions

are the only ones that can be used, nor that they are in every case the simplest and shortest. There are a great many convenient and accurate curves and charts which give, almost at a glance, the load components, corrective kv.a. and resultant power factor. There is, however, a tendency to use such time saving expedients blindly, and with no knowledge of the principles involved—a procedure which leaves the engineer helpless if the curve that fits the problem in hand is not available.

Load Triangle Forms Basis of Preceding Methods

All of the preceding methods of solving for any of the unknown factors are based on the construction of a load triangle and the application of the simple arithmetical rule for finding the hypotenuse of a right triangle. The rules for the geometrical construction are simple and being almost self-evident, are easily remembered.

Rule 1. The reactive and power components are drawn at right angles to each other.

This is obvious from the fact that they are 90 deg. displaced from each other electrically.

Rule 2. Leading and lagging reactive components are laid out in opposite directions.

In other words, if lagging reactive kilovolt-amperes are measured towards the top of the paper, leading reactive kilovolt-amperes will be measured towards the bottom.

Rule 3. The resultant reactive current is equal to the difference between the leading and the lagging reactive kilovolt-amperes.

This is obvious from the fact that these components tend to cancel each other.

Rule 4. With known reactive and power components, the total kilovolt-amperes is equal to the square root of the sum of their squares, and corresponds graphically to the hypotenuse of a right triangle of which they form the other two sides.

Rule 5. The power factor is at any time equal to the quotient obtained by dividing the power component by the total kilovolt-amperes, i. e., kw. ÷ kv.a.

This power factor may be either leading or lagging, depending on the phase position of the reactive component. In a problem involving the resultant power factor after the addition of corrective capacity to an original load, this position is in turn determined by the relative arithmetical value of the original and the added reactive components.

Electricity---What It Is and How It Acts

Part IV. Arrangement of Electrons in the Atoms of Various Elements. Why Atoms Possess Certain Properties

HAVING LEARNED something about the general structure of the atom and the principles underlying the process of chemical combination, we will now consider in some detail the actual arrangement of electrons in the atoms of the various chemical elements.

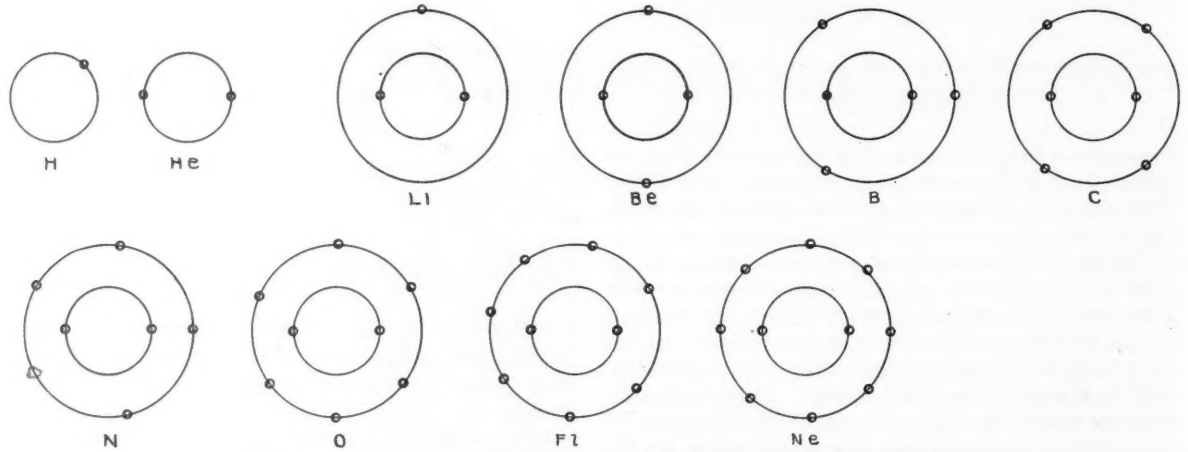


FIG. 1. A SIMPLE REPRESENTATION OF THE TEN LIGHTEST ATOMS

The hydrogen atom, we have seen, has only one electron revolving around its nucleus, while the helium atom has two. These two electrons are probably disposed on diametrically opposite sides of the circle, forming a stable arrangement, which probably accounts for the inertness of this element. It is perfectly satisfied and there is no tendency to acquire or lose electrons.

With three electrons in an atom, a different arrangement obtains. The ring holding the two electrons of the helium atom is stable and cannot accommodate any additional electrons, so when the excess positive charge on the nucleus is such that the atom requires three external electrons, the third is disposed in an orbit by itself which is just twice as far from the nucleus as the inner ring and capable, therefore, of accommodating four times as many electrons. Thus, this next orbit requires 8 electrons to form a perfectly stable system and the atom which satisfies this requirement is that of a gas called neon. This is the gas which is being used in those red orange electric sign lamps so common at the present time. The atom of neon has ten electrons, two in the inner ring and 8 in the outer. See Fig. 1.

Between the two stable atoms, helium and neon,

there are seven atoms (see table), each differing by an external electron, which have a tendency to acquire or lose electrons depending upon whether the systems are closer to the helium or neon atoms in the table. It is easier for lithium, which has only one electron in the second orbit, to lose an electron, producing the stable arrangement of the helium atom, than it is to acquire 7 electrons, to give it the 8 required. Similarly, in the case of beryllium, which has 4 electrons in the second ring, it it easier to lose 2 than to acquire 6. The same is true of boron, which prefers to part with 3 rather than to acquire 5. Thus, because they would rather give up electrons than lose them, all of these elements, lithium, beryllium and boron, are said to be electro-negative.

According to the same line of reasoning, nitrogen, oxygen and fluorine, which have respectively 5, 6 and 7 electrons in the outer ring or shell, are electro-negative. It is easier for these atoms to acquire electrons to give them the number required for stability than to lose them. Fluorine tends to acquire one electron and is said to have a negative valence of one and a positive valence of seven.

We have now accounted for all the atoms between helium and neon except one, namely the all-important element, carbon, with four external electrons in the outer ring. This system is midway between the helium and neon atoms and its positive and negative valences are equal. It has four electrons in its second shell and since they repel each other, probably assume positions such as form the corners of a solid figure of four equal sides. A system of this kind, which will as readily part with electrons as acquire them, should combine readily with other atoms and this happens to be the case. Carbon enters into all organic compounds.

Proceeding now to one atom with eleven electrons, we again find that the extra electron (over the number giving the stable system of neon) must find its place in a third orbit or outer shell. This third shell is practically coincident with the second and is capable of accommodating the same number of electrons, namely eight. The first element having this third shell is sodium, consisting of a nucleus with an excess positive charge of eleven, an inner shell with two electrons, a second shell twice as far from the nucleus as the first shell with 8 electrons and a third outer shell with one electron. Sodium, therefore, is in much the same condition as lithium, that is, it has a tendency to lose the outermost electron to give it the stability of the neon atom. Like the lithium atom, it has an electro-negative valence of one, and an electropositive valence of seven. The next element (table), magnesium, has two electrons in the third shell and, like beryllium, has an electro-negative valence of two and an electropositive valence of six.

So we proceed, adding an electron in the outer ring, until we come to argon, with 8 electrons in the third shell. This system, like that of neon, is stable and there is no tendency for this atom to acquire or lose electrons.

PARTIAL LIST OF THE CHEMICAL ELEMENTS ARRANGED IN THE ORDER OF THEIR ATOMIC NUMBERS

1. Hydrogen	H	28. Nickel	Ni
2. Helium*	He	29. Copper	Cu
3. Lithium	Li	30. Zinc	Zn
4. Beryllium	Be	31. Gallium	Ga
5. Boron	B	32. Germanium	Ge
6. Carbon	C	33. Arsenic	As
7. Nitrogen	N	34. Selenium	Se
8. Oxygen	O	35. Bromine	Br
9. Fluorine	Fl	36. Krypton*	Kr
10. Neon*	Ne	37. Rubidium	Rb
11. Sodium	Na	38. Strontium	Sr
12. Magnesium	Mg	39. Yttrium	Y
13. Aluminum	Al	40. Zirconium	Zr
14. Silicon	Si	41. Niobium	Nb
15. Phosphorus	P	42. Molybdenum	Mo
16. Sulphur	S	43.	
17. Chlorine	Cl	44. Ruthenium	Ru
18. Argon*	A	45. Rhodium	Rh
19. Potassium	K	46. Palladium	Pd
20. Calcium	Ca	47. Silver	Ag
21. Scandium	Sc	48. Cadmium	Cd
22. Titanium	Ti	49. Indium	In
23. Vanadium	V	50. Tin	Sn
24. Chromium	Cr	51. Antimony	Sb
25. Manganese	Mn	52. Tellurium	Te
26. Iron	Fe	53. Iodine	I
27. Cobalt	Co	54. Xenon*	X

*Transition systems.

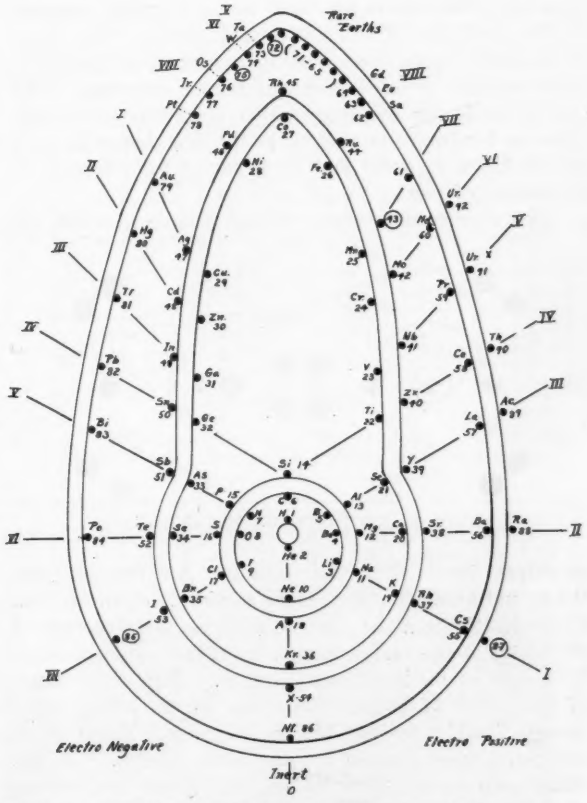


FIG. 2. ATOMIC SYSTEMS AT THE PERIODIC TABLE. PLACE NUMBERS CORRESPOND TO ATOMIC NUMBERS. SYSTEMS SIMILARLY SITUATED, AS INDICATED BY RADIAL LINES, HAVE SIMILAR CHEMICAL PROPERTIES. FROM JOHN MILLS' "WITHIN THE ATOM"

Midway between neon and argon is the element silicon, which has the atmospheric properties of carbon. It has 4 electrons in the third shell and will as readily part with them as acquire 4 additional electrons.

From what has thus far been said, it must be obvious that in progressing from the simple hydrogen atom through those more complex structures, there is a periodic recurrence of systems with similar properties. At certain points, stable or satisfied systems are reached, which are transition systems between those of positive and negative valence. These are the inert gases, helium, neon and argon, etc.

So far, we have accounted for 18 of the 92 different elements. The others are built up in a similar manner by the addition of other external shells. The outer shells differ from those already described in that they have capacity for a larger number of electrons. The fourth shell, for instance, which is presumably three times as far from the nucleus as the first, hence its area is nine times as great and its capacity for electrons is 18 instead of two.

As we proceed to atoms of high atomic number, the

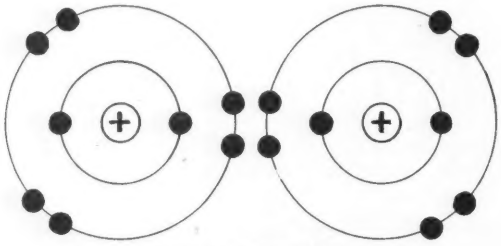


FIG. 3. THE OXYGEN MOLECULE

principles involved in their structure are the same but the actual arrangement is more complex. John Mills in his book, "Within the Atom", explains the structure of the atoms of the various atoms in an interesting manner by means of an ingenious diagram. This is a picture of the series of atomic structures as if there were a group of tables to be filled in by guests. These tables are roughly concentric as shown in Fig. 2. In Mr. Mills' own words, "one by one the atomic systems are seated and the order of their seating is given by the atomic numbers attached to their places. The first table seats only two; the next table, eight on each side; the third table, seating 18 on each side, must place some atomic systems in positions which do not correspond with any of those at the second table. There is, however, a correspondence between atomic systems which are opposite to one another at the same table. The fourth table differs in some ways from any of the inner ones and on one side it is only partially filled."

In representing the atomic systems in this manner, those elements which have similar characteristics lie on the same radial line. The radial line on which the stable or inert systems lie is marked zero. The others are marked with Roman numerals for the convenience of those who wish to compare this diagram with the usual tabular presentation of the periodic series of the chemical elements. The elements grouped on the right side of the plan are electro-positive while those on the left are electro-negative.

This arrangement, then, not only accounts for all of the 92 elements but gives us the reason for some of their properties. It tells us, for instance, that sodium (Na) combines with chlorine (Cl) to form sodium chloride (NaCl) which is our common table salt. By referring to the diagram, it will be seen that sodium with an atomic number of 11 has a positive valence of 1, while chlorine with an atomic number of 17 has a negative valence of 1. One is willing to give up an electron while the other has a tendency to acquire one. Hence the two systems combine to satisfy their respective desires.

In a similar manner, atoms of the same element combine. Oxygen with 8 electrons, for instance, lacks two to satisfy the requirements of its outer ring. Two atoms of oxygen, therefore, will combine into the molecule shown in Fig. 3. In this case, four electrons are shared by two atoms. Of course, in this case there are not enough electrons to "go round" but by remaining close together, each atom is in a manner responsible for two electrons in the adjacent system. While the two valency shells do not contain the sum of 16 electrons, each atom in effect has 8 in its valency shell. This is the reason why, in nature, oxygen is always found combined in molecules of two atoms each.

We have considered the arrangement of electrons within the atom in considerable detail because these electrons play an important part in electrical phenomena of all kinds. All electrical properties of conductors, solid, liquid and gaseous, are explained in terms of these electrons. In the next article we will discuss the various kinds of electrical conductors.

A.S.M.E. Plans Summer Meeting at Twin Cities

PRECEDED BY a beautiful vacation lake trip, featuring an excellent program of inspiring addresses, discussion-provoking technical papers and splendid entertainment, the summer meeting of the American Society of Mechanical Engineers at St. Paul and Minneapolis, August 27 to 30, has recently been announced.

About 200 members from the east are planning to join the boat which leaves Buffalo on August 20. After stops at Cleveland, Detroit, Mackinac Island, the Soo Canal and Houghton, the boat will dock at Duluth on August 25, when the local engineers are planning to reveal the mysteries of mining to the visiting mechanical men. Then, after a jump to Winnipeg to enjoy the hospitality of the Winnipeg Branch of the Engineering Institute of Canada, the excursion will arrive at St. Paul on Monday, August 27.

Headquarters of the meeting will be at the St. Paul Hotel. Here all of the technical sessions will be held and a portion of the entertainment events. Monday morning will be given over to the Council Meeting,

Outstanding program event will be the dinner on Wednesday evening at the St. Paul Hotel. The presence of Thomas D. Campbell of Hardin, Mont., and Ralph G. Budd, president of the Great Northern Railway, as speakers on this occasion, marks it as outstanding. Mr. Campbell farms 95,000 acres. He is a graduate engineer and operates his farm on the same basis as a great industry. He will show moving pictures of his methods and describe their relation to modern engineering.

Production and Utilization of Compressed Air

PART I. MANY TYPES OF MACHINES, DRIVEN IN VARIOUS WAYS, ARE AVAILABLE TO MEET ALMOST UNIVERSAL DEMANDS FOR THE POWER PLANT COMPRESSED AIR SUPPLY

AMONG THE MANY FACTORS that constitute the component parts of a modern power plant, compressed air is, with the exception of the electric generator, probably the most universal. Seldom is a power plant, whether it be steam, hydro or oil engine, built without being equipped with some type of air compressor. Sometimes it is installed for a specific purpose, but usually as a general service for the plant as a whole.

Usually for standard pressures of from 55 to 125 lb. per sq. in., the single or two-stage reciprocating compressor with steam, internal combustion engine or motor

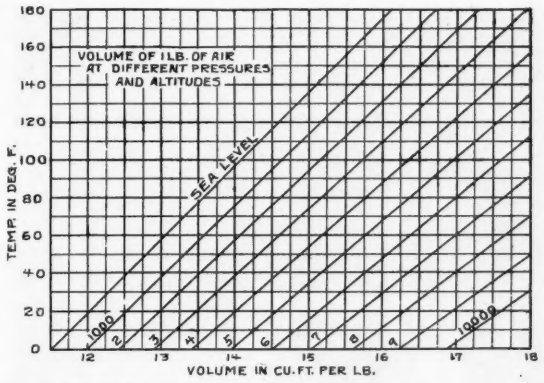


FIG. 1. VOLUME OF 1 LB. OF AIR IN CU. FT. AT VARIOUS TEMPERATURES AND PRESSURES

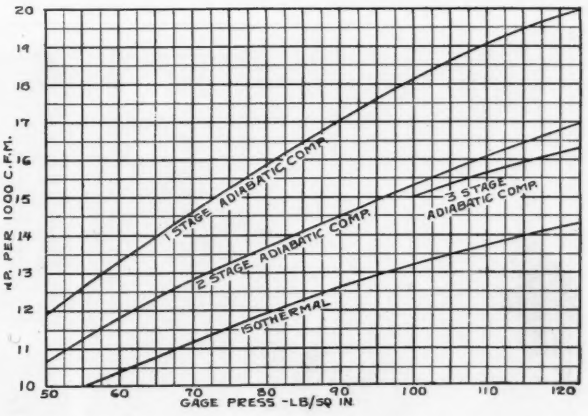


FIG. 2. CURVES SHOWING THE VARIATION OF HORSEPOWER WITH DIFFERENT FORMS OF COMPRESSION

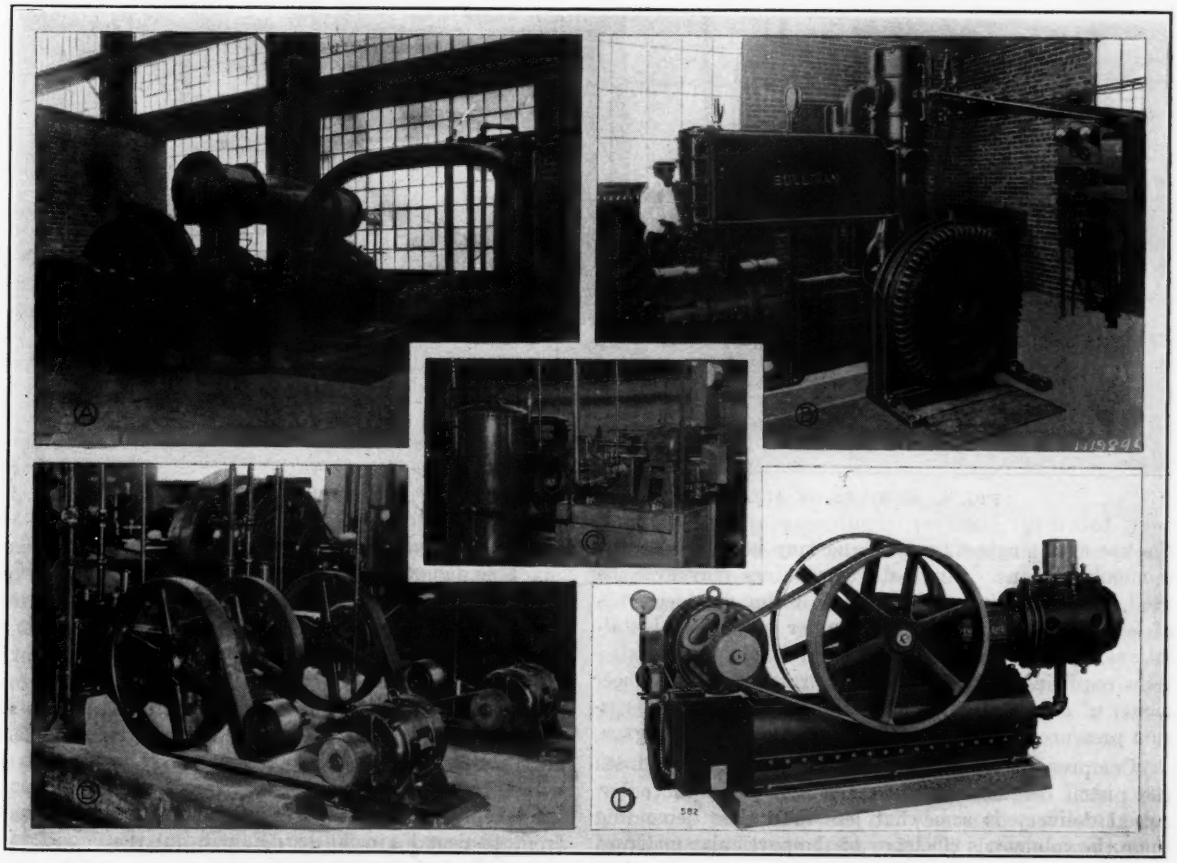


FIG. 3. SEVERAL ARRANGEMENTS OF MOTOR DRIVE FOR AIR COMPRESSORS

drive is used. Determining the economical dividing line between single and two-stage compression is not exact as there must of necessity be some overlapping due to different conditions.

For pressures up to 60 lb. per sq. in. gage, single stage should be used. Between 60 and 100 lb., the division between single and two-stage compression will depend largely upon first cost, capacity required, cost of power, altitude and whether or not the installation will be permanent.

There is no doubt that multistage compression is more efficient where the pressure is over 60 lb., although

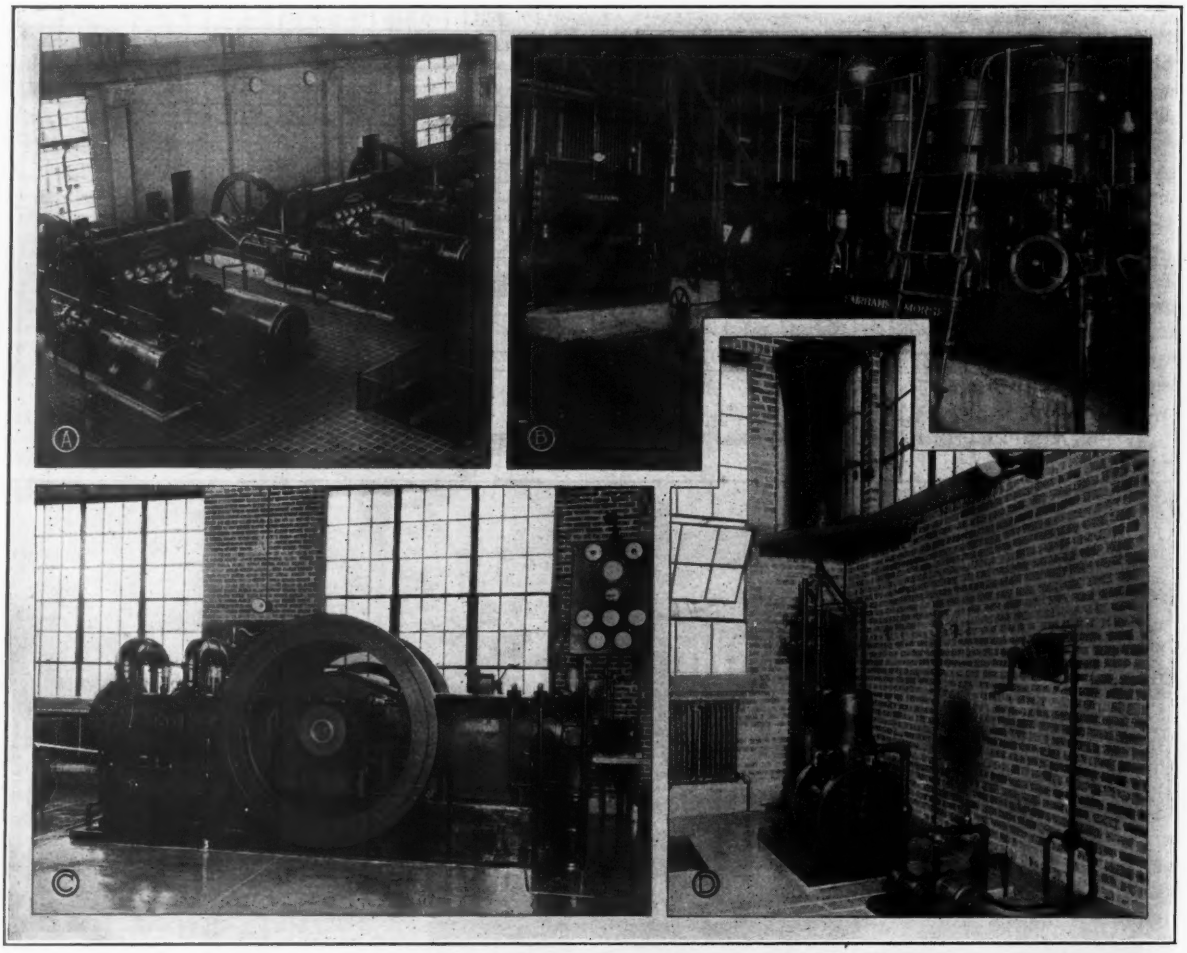


FIG. 4. ENGINES OF ALL TYPES ARE WELL ADAPTABLE TO COMPRESSOR DRIVE

the use of a single-stage machine may be advisable for economic reasons. Single-stage machines may even be used with pressures as high as 110 lb. for displacements of less than 350 c.f.m. Generally for permanent installations, two-stage compression is advisable for installations requiring more than 100 lb. pressure and displacements of over 300 c.f.m. Standard two-stage compression pressures range from 100 to 125 lb. per sq. in. gage.

Compressors are ordinarily rated in accordance with the piston displacement in cubic feet per minute but actual delivery is somewhat less than this, depending upon the volumetric efficiency of the particular machine. Free air is used in designating the delivery and by free air is meant air at normal atmospheric conditions prevailing at the time. Because of the altitude, barometric and temperature variations at different localities, the term does not always mean air under the same identical conditions.

For ordinary pressures and temperatures, the volume of a given weight of air can be found from the relation:

$$PV = 0.37WT$$

where

P = pressure in pounds per sq. in. absolute
V = volume in cubic feet
W = weight of air in pounds
T = temperature in deg. F. absolute = T + 460

It is evident that both temperature and altitude affect the capacity of the compressor, the volume of 1 lb. of air for different temperatures and altitudes varying as shown in Fig. 1. As the weight of a cubic foot of air decreases when the temperature and altitude increase, the weight of air handled by a given machine must decrease also. At 6000 ft. altitude, a compressor will handle but 80 per cent as much by weight as at sea level while increasing the suction air temperature from 40 deg. F. to 90 deg. F. will cut the capacity to about 89 per cent of its former value. As the com-

pressor handles less air under these conditions the power consumption will decrease; for instance a single-stage, 100-lb. gage compressor will require only about 90 per cent as much power at 6000 ft. elevation as at sea level.

Theoretical power consumption curves for one, two and three-stage compression are shown in Fig 2 for both isothermal and adiabatic compression. In isothermal compression, the gas temperature is assumed constant, while in adiabatic compression, the temperature rises unchecked for each stage but is cooled to the temperature of isothermal compression between each stage. In isothermal compression, the power is the same for all types of machines, regardless of the number of stages.

Many different drives are available to meet all conditions of service and installation. Roughly, they are grouped in the accompanying classification, in which rope drives and various other patented devices have been included with belts. Figure 3 shows five types of motor drive; Fig. 3A, a large multibearing machine with the synchronous motor mounted directly on the crankshaft; Fig. 3B, overhung synchronous motor on the crankshaft; Fig. 3C, geared; Fig. 3D, patented close belt drive, and Fig. 3E, close belt. Figure 3A also shows an aftercooler which is advisable in many industries. By cooling the air, much of the moisture is condensed in the intercooler from which it can be drained out through a blowoff valve. By carrying the cooling far enough, any desired degree of dryness can be obtained. Cooling surface of about 16 sq. ft. per 100 c.f.m. is usually provided. Other drives are shown in Fig. 4; Fig. 4A is a large installation of steam-driven machines, Fig. 4B is an oil engine drive, direct connected through a friction clutch, Fig. 4C is an opposed piston type oil engine-driven machine in which the compressor and engine are built as a single unit, Fig. 4D is a small direct connected gas engine-driven compressor installed in a Diesel plant for supplying starting air for the engines.

CLASSIFICATION OF THE MAIN TYPES OF COMPRESSOR DRIVE

1. Motor Drive
   - 1.1 Belt
     - 1.11 Belt
     - 1.12 Close belt
   - 1.2 Direct connected
     - 1.21 Gear drive
     - 1.22 Motor on crankshaft
       - 1,221 Multi-bearing
       - 1.222 Overhung
2. Engine Drive
   - 2.1 Steam engine
     - 2.11 Belt drive
     - 2.12 Steam cylinder in tandem with air cylinder
   - 2.2 Gas engine
   - 2.3 Oil engine
     - 2.31 Opposed piston
     - 2.32 Direct connected
     - 2.33 Belt

(To be concluded.)

Testing Brine for Presence of Ammonia

SIMPLE CHEMICAL TESTS, WHICH ANYBODY CAN PERFORM WITHOUT ELABORATE EQUIPMENT, DETECT MINUTE TRACES OF AMMONIA IN BRINE. BY C. E. ANDERSON

DURING THE PAST season, the writer encountered several occasions when it was necessary to test brine for the presence of ammonia and found that Nessler's reagent or litmus paper tests could not always be relied upon. Under certain conditions, they are accurate but these conditions do not prevail at all times.

We will take up Nessler's reagent first. Nessler's reagent is made in the following manner: Dissolve 17 grams of mercuric chloride in 300 c.c. of distilled water, dissolve 35 grams of potassium iodide in 100 c.c. of distilled water; add the chloride solution to the iodide solution (slowly stirring the mixture with a glass rod) until a slight red precipitate is found that will remain in spite of the stirring. Do not add any more chloride. You will find that there will be some of this chloride solution left over.

Next dissolve 120 grams of potassium hydrate in 200 c.c. of water, allowing this solution to cool. When cool, add this to the chloride and iodide mixture and make up with water to one liter (1.05 qt.).

When this is done, add mercuric chloride solution, constantly stirring until a permanent precipitate again forms—then stop. Allow this mixture to stand until the precipitate settles, which will take a day, sometimes more. Then draw off the clear liquid into a blue or brown glass-stoppered bottle and keep it away from light as much as possible, in order to keep it from decomposing.

AMMONIA TEST

To test for ammonia, take a small glass—if you wish to be really fancy, take a test tube—fill it three-quarters full of brine or water, as the case may be, and add a few drops of Nessler's reagent. If it turns yellow, there is a slight amount of ammonia present. If it turns brown, there is a correspondingly larger amount of ammonia present.

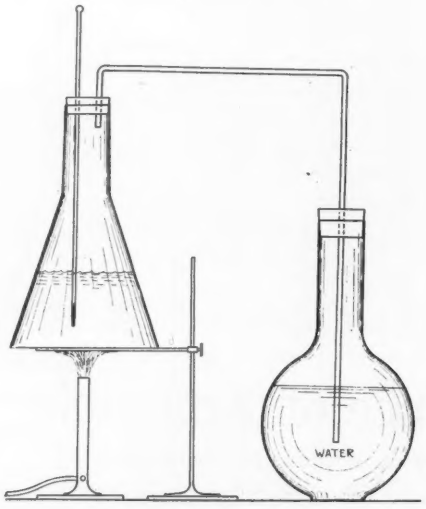
This test is exceedingly accurate, provided your reagent is fresh or fairly so, and has not decomposed, due to being exposed to the light.

Nine times out of ten, when this test is used it will be found that the solution is old or decomposed, hence useless. To procure a fresh supply takes two days, as the liquid must stand until clear, as previously explained. This is out of the question when in a hurry, and here we are considering the problem from the trouble man's or consulting engineer's standpoint, where he has been called into a plant to diagnose their troubles and suggest remedies, etc. If there is sufficient time, by all means have a fresh solution made up and use it for testing.

The next test we will consider is the litmus or sensitive paper test.

There are a great many sensitive papers that can be used in testing for ammonia, but we will consider only a few of the more common ones. Since ammonia is an alkali, almost any paper that will test for an alkali can be used in testing for ammonia. The white test paper, which the different ammonia manufacturers give away, is the best known and the most familiar one to most of us. This paper is especially prepared for detecting the presence of ammonia in brine water and air. If ammonia is present, the paper will turn pink or red, depending upon the quantity of ammonia present. Pink is for a slight amount and red when there is a correspondingly larger amount present.

The great fault with this test paper and the outstanding one is that the paper is not sensitive enough.



ARRANGEMENT OF APPARATUS FOR MAKING AMMONIA TEST

When the paper indicates the presence of ammonia, the sense of smell will detect it, also, thus it really is only a good check on your nose and smelling power, or vice versa.

There is another sensitive paper that is familiar, namely the red litmus paper. This paper is used to test for an alkali and is generally made in three strengths or three grades of sensitiveness. This paper will turn blue when there is any ammonia present. The three generally used grades are the ones that respond to one part of ammonia in 100 parts brine or water; one part of ammonia in 250 parts brine or water and one part ammonia in 1000 parts of brine or water. The paper for the 1 to 1000 is exceedingly good but has the disadvantage of decomposing when subject to light or air for any length of time, hence it becomes useless as a testing agent. The 1 to 100 and 1 to 250 are useless for testing for ammonia, as one can smell the ammonia in the water, brine or air a long time before either one of these two grades of paper will indicate its presence.

Some method of testing brine or water for ammonia that is sure, simple and inexpensive and that can be used anywhere is what is required.

Such an apparatus has been used by the writer for some time and its use has given the best of results. The writer makes no claim for discovering this method nor does he claim any novelty for it, as it is only well known chemical characteristics of the different elements applied and made use of. The apparatus and its workings are similar to the absorption system of refrigeration —in fact, it was from this system that the writer derived the idea of making and using this apparatus in testing brine and water for the presence of ammonia.

Description of Apparatus Required

As shown in the sketch, the apparatus consists of the following material:

One small Bunsen burner and rubber gas tubing.
One 1½-pint Erlenmeyer flask.
One pint round chemical flask.
One thermometer, straight stem, graduated to 250 deg. F. or 120 deg. C.
One rubber cork, to fit flask with two openings.
One rubber cork to fit flask with one opening.
One adjustable stand to hold flask.

Piece of bent glass tubing to fit into corks of both flasks, as per sketch, being sure that one end of glass tubing goes down below the water level and about an inch from the bottom of the lower flask.

To start the apparatus working, we fill the lower or absorption flask about half full of water, being sure that the end of the glass tube is covered. The Erlenmeyer flask is next filled about half full of the liquid we suspect of containing ammonia, brine or water, as the case may be.

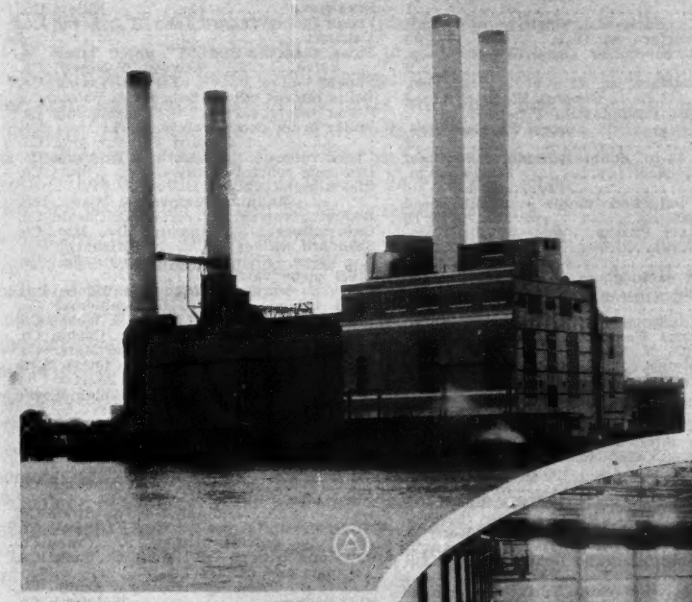
Light the burner and place it underneath the Erlenmeyer flask and heat this brine or water up to a temperature of 200 deg. F. or 93 deg. C. for a period of 15 min., being certain not to allow the liquid to exceed these temperatures, thereby causing a pressure on the apparatus due to boiling and forming steam.

After this liquid has been held at this temperature for 15 min. or so, remove the flame and empty the Erlenmeyer flask, fill it with brine or water once more and go through the same heating process again. Repeat this about five or six times, then remove the lower flask and test this water with Nessler's reagent, litmus paper or with the sense of smell. If there is any ammonia in the brine or water that was heated, it will surely show up in the water of the lower flask.

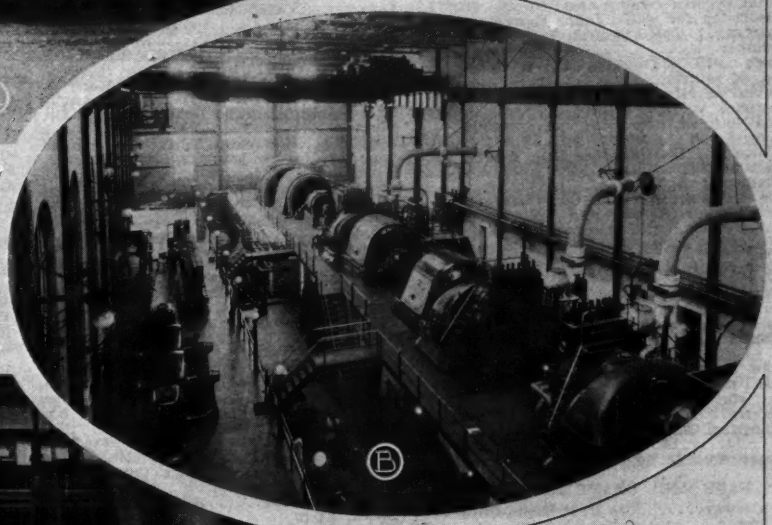
The underlying principle of this apparatus is the natural affinity of water for ammonia. Under ordinary circumstances, water at a temperature of 68 deg. will absorb about 683 times its own volume of ammonia gas and as the temperature of the water decreases, the absorption of ammonia gas increases rapidly. At 35 deg., water will absorb 1120 times its own volume of ammonia gas. From the foregoing, we see that better results will be had with this apparatus if the lower or absorption flask is set in a dish or container and covered with cracked ice, in order to keep the water temperature as low as possible.

The reason for using an Erlenmeyer flask in the generating side of this apparatus is that the flask is wide and gives a large area to the surface of the liquid to be heated, so that the ammonia gas, if there is any entrained, is driven off gently and quickly.

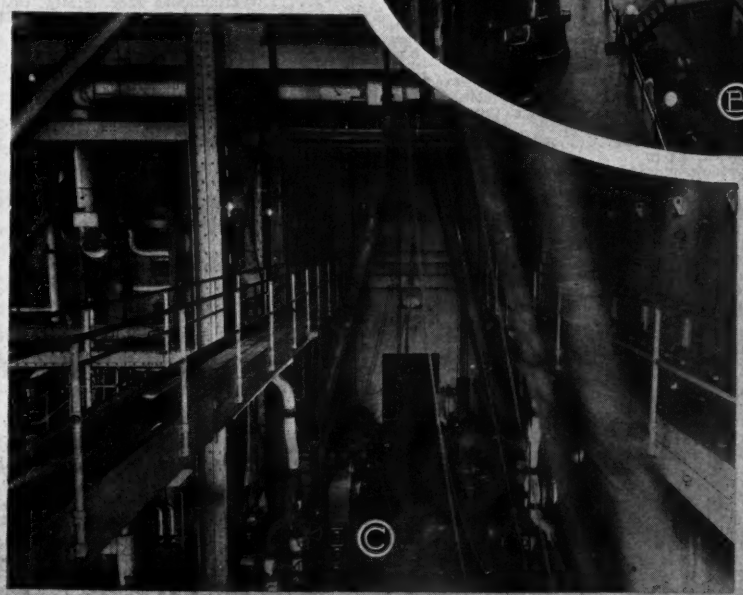
Reeves Avenue Station at Norfolk Adds 30,000-Kw. Unit



A—At the right is the extension containing three 1865-hp. boilers and a 30,000-kw. turbine-generator. Rapid increase in power demands of the Norfolk district necessitated installation of equipment of the most modern type. Stone & Webster, Inc., designed and constructed this addition, which brings the total present capacity of the station to 90,000 kw.



B—Looking east in the enlarged turbine room, showing the new unit at the farther end. Power is generated at 11,000 v.



C—Three new boilers are fired by underfeed stokers with a complete automatic combustion control system. Steam is generated at 450 lb. pressure. 725 deg. total temperature. Furnaces are water-cooled and incorporate latest principles of design, providing for operation at maximum of 400 per cent of rating.

Principal Equipment in Reeves Avenue Power Station Addition

GENERAL

LOCATION ..... Norfolk, Va.
CAPACITY
Present, addition ..... 30,000 kw.
Ultimate, addition ..... 62,500 kw.
Present, entire ..... 90,000 kw.
BUILT FOR.... Virginia Elec. & Power Co.
ENGINEERS AND CONTRACTORS .....
..... Stone & Webster, Inc.
SUPERINTENDENT of Production, V. E. & P. Co..... J. W. Keeney
CHIEF ENGINEER, Reeves Ave. Power Station ..... J. H. Berry

BOILER EQUIPMENT

BOILERS..... Babcock & Wilcox Co.
Number 3
Type..... Cross drum water tube
Heating surface, sq. ft..... 18,651
Steam pressure, lb. per sq. in. gage... 450
Steam temperature, deg. F..... 725
Normal rating, per cent..... 200
Maximum rating, per cent..... 400
Lb. steam evaporated per hour, 400 per cent rating..... 240,000
SUPERHEATERS..... Babcock & Wilcox Co.
Number 3
Type ..... Interdeck—4 loop
Degrees superheat, deg. F..... 265
FURNACE WALLS (Bailey) Fuller Lehigh Co.
Number sets 3
Type ..... Water cooled
Exposed cooling area, two side walls, sq. ft. 322
Exposed cooling area, downtake walls, sq. ft. 350
Total exposed cooling area, sq. ft..... 672
Insulation for walls..Johns-Manville Corp.
STOKERS....The American Engineering Co.
Number 3
Type ..... Taylor Underfeed
No. of retorts..... 13
Actual effective grate surface, sq. ft...429
Furnace volume, cu. ft..... 7200
Coal burned per hour, max. rating, lb. 29,500
MOTORS.... Westinghouse Elec. & Mfg. Co.
Capacity, hp. 12
FIREBRICK & TILE.....
Babcock & Wilcox Co., Harbison-Walker Refractories Co., Celite Products Co., George Allen & Son Queen's Run Refractories Co.

COAL AND ASH HANDLING

TRACK HOPPERS, Belt conveyors, Pan feeder conveyor .....
.....Stephens-Adamson Mfg. Co.
Capacity of coal handling equipment.. ..... 135 t. per hr.
ASH EQUIPMENT
Ash hoppers, clinker chambers, ash sluiceway. The Allen-Sherman-Hoff Co.
CRANE..... Northern Engineering Co.
CLINKER GRINDERS .....
.....The American Engineering Co.
DRAG SCRAPER. Stephens-Adamson Mfg. Co.

FANS AND DRAFT EQUIPMENT

CHIMNEY..... The Rust Engineering Co.
Number 2
Material..... Concrete, brick lined
Diameter ..... 13 ft.
Height ..... 135 ft. 5 in.
SMOKE FLUES..... Connery & Co., Inc.
BOILER UP-TAKE FLUES.....
.....Connery & Co., Inc.
FORCED DRAFT DUCTS, SIFTING HOPPER .....Connery & Co., Inc.
FORCED DRAFT FANS AND DAMPERS..
.....The Green Fuel Economizer Co.
Number 6
Type..... Double width, radial flow
Capacity, c.f.m. at 70 deg. F..... 50,000
Static head..... 13 in. of H_2O
Drive..... 25-hp. induction motor
FAN UNIT—SWITCH HOUSE
Fan..... American Blower Co.
Number 1
Type ..... No. 5 "Sirocco"
Drive ..... 15-hp. induction motor
UTILITY BLOWER.... American Blower Co.
Type ..... No. 1—Utility
Number 1
Drive ..... Motor

PRIME MOVERS AND AUXILIARIES

TURBINE GENERATOR .....
.....Westinghouse Elec. & Mfg. Co.
Number 1
Capacity ..... 30,000 kw.
Steam pressure, throttle, lb. sq. in. gage 400
Steam temperature, throttle, deg. F...700
Steam pressure, exhaust, inches Hg. abs. 1½
Speed, r.p.m. 1800
Type..... Condensing, single unit, single cylinder, combination, Westinghouse impulse and reaction
CONDENSER, MAIN .....
Wheeler Condenser & Engineering Co., now Foster Wheeler Corp.
Number 1
Type..... Horizontal, single pass, surface
Cooling surface, sq. ft..... 25,200
Condenser air cooler. Foster Wheeler Corp.
Number 2
Cooling surface, sq. ft..... 2000
Tubes..... General Electric, finned
CONDENSER CIRCULATING PUMP.....
.....Foster Wheeler Corp.
Number 2
Type....36-in. double suction, centrifugal
Capacity, each..... 34,500 g.p.m.
Drive ..... 2—125-hp. induction motor constant speed
Head, feet 15
CONDENSATE PUMPS..Foster Wheeler Corp.
Number 2
Type ..... 5-in. two stage
Capacity, each, g.p.m..... 750
Head, feet 225
Drive ..... 2—100-hp. induction motor constant speed
OIL COOLERS. Westinghouse Elec. & Mfg. Co.
Type..... Vertical straight tube type
OIL PURIFIER..... DeLaval Separator Co.
STEAM JET AIR PUMPS.....
.....Foster Wheeler Corp.
Number units 2
Type ..... Surface inter and after condenser type
TRAVELING WATER SCREENS..Link-Belt Co.
Number 1
Size ..... 8 ft. 8¼ in.
Drive ..... 4½-hp. motor
AUXILIARY OIL PUMP.....
.....Westinghouse Elec. & Mfg. Co.

EVAPORATOR AND HEATERS

EVAPORATOR..... The Griscom-Russell Co.
Number 1
Type..... Horizontal bentube submerged
Capacity, lbs. per hour..... 11,000 at 250 deg. F. into vapor at 30.1 lb. abs., steam at 76 lb. 97 deg. superheat
Heating surface, sq. ft..... 346
DEAERATING HEATER..... Elliott Co.
Number 1
Type ..... Open heater
Capacity, lb. of condensate per hr..376,000
EVAPORATOR CONDENSER..... Elliott Co.
Number 1
Type ..... Surface
Water circulated, lb. per hr..... 376,000
SURGE TANK..... Elliott Co.
FEEDWATER HEATERS .....
.....Schutte & Koerting Co.
Number ..... 2-l.p. and 2 h.p.
Type..... "U" tube bleeder
Surface, sq. ft..... 1735-l.p., 2020 h.p.

PUMPS

BOILER FEED PUMPS.... Ingersoll-Rand Co.
Number..2 motor driven, 1 turbine driven
Type..... 6-stage Cameron hp.
Capacity, g.p.m. 960
Head..... 540 lb. or 1212 ft.
Speed, r.p.m. 1750
Drive..... 400-hp. motor, 400-hp. turbine
CITY WATER PUMPS..... Ingersoll-Rand Co.
Number 2
Type ..... Single stage
Capacity, g.p.m. 1000
Drive..... 20-hp. induction motor
SALT WATER AUXILIARY PUMPS.....
.....Ingersoll-Rand Co.
Number 3
Type ..... Single stage
Capacity, g.p.m. 1000
Total head, feet..... 300
Drive..... 150-hp. induction motor
FEEDWATER BOOSTER PUMPS.....
.....Ingersoll-Rand Co.
Number 2
Type ..... Single stage
Capacity, g.p.m. 800
Drive..... 40-hp. induction motor
DRIP PUMPS, LOW PRESSURE.....
..... Ingersoll-Rand Co.
Capacity, g.p.m. 100
DRIP PUMPS, HIGH PRESSURE.....
..... Ingersoll-Rand Co.
Capacity, g.p.m. 250
BILGE PUMP..... Power Equipment Co.

OTHER MECHANICAL EQUIPMENT

CRANES ..... The Cleveland Crane & Engineering Co.
Location ..... Turbine room
Type ..... 100-t., traveling
SOOT BLOWERS .....
.....Diamond Power Specialty Corp.
REDUCING VALVES, Control, and De-superheating Equipment .....
.....Smoot Engineering Corp.
PIPE COVERING AND HEAT INSULATION .....Keasbey & Mattison Co.
WATER COLUMNS....Babcock & Wilcox Co.
WATER COLUMN ILLUMINATORS.....
..... National Co.
STEAM GAGE, Main.....Foxboro Co.
FEEDWATER CONTROLLERS.....Stets Co
STRAINERS ..... Elliott Co.
FLOOR DRAIN TRAPS..John T. Donovan Co.
VALVES:
Float chamber and "V" notch lever valve.....Atwood & Morrill Co.
Blowoff valves.....Yarnall-Waring Co.
Boiler blowoff valves. Babcock & Wilcox Co.
Boiler safety valves.....Consolidated Co.
Boiler drum check valves.....
.....Edward Valve & Mfg. Co.
Check valves.....Schutte & Koerting Co.
Drainage controller valve.....Stets Co.
Steam relief valves.....
.....Manning, Maxwell & Moore, Inc.
Reducing valves.....W. D. Cashin Co.
Gate valves.....Chapman Valve Mfg. Co.
Standard valves .....Pittsburgh Valve, Foundry & Construction Co.
Steel globe valves.....
....Manning, Maxwell & Moore, Inc.
Steel valves.....Lunkenheimer Co.
GEAR HOIST.....Clinton E. Hobbs Co.
PUMP GOVERNOR.....W. D. Cashin Co.
WATER METER.....Neptune Meter Co.
BELL TRAPS.....J. B. Clow & Sons
OIL STORAGE TANK.....
.....Coatesville Boiler Works
MAIN STEAM PIPE AND FITTINGS.....
..... Pittsburgh Valve, Foundry & Construction Co.
MISCELLANEOUS PIPE AND FITTINGS:
Forged steel flanges and fittings....
.....Henry Vogt Machine Co.
Steel pipe fittings.....
.....Lumsden & Van Stone Co.
Steel pipe.....W. K. Mitchell Co.
Steel pipe and C.I. fittings.....Crane Co.
Pipe and fittings.....Benj. F. Shaw Co.
C.I. pipe and fittings.....
.....Pittsburgh Piping & Equip. Co.
C.I. fittings.....Walworth Co.
Black steel pipe.....Tippett and Wood
C.I. Bell & Spigot pipe.....
..U. S. Cast Iron Pipe & Foundry Co.

ELECTRICAL EQUIPMENT

MAIN GENERATOR .....
.....Westinghouse Elec. & Mfg. Co.
Number 1
Capacity....30,000 kw. at 80 per cent p.f.
Speed, r.p.m. 1800
Voltage....11,000 v., 3-phase, 60 cycles
Exciter...25 kw., 250 v., direct connected
AUXILIARY GENERATOR .....
.....Westinghouse Elec. & Mfg. Co.
Number 1
Drive..Direct connected to main generator
Capacity.....1250 kw., 80 per cent p.f.
Voltage.....2300 v., 3-phase, 60 cycles
MOTOR DRIVEN EXCITER SETS.....
.....General Electric Co.
Number 2
Capacity ..... 150 kw.
GENERATOR FIELD and Exciter Switchboard.....General Electric Co.
GENERATOR AIR COOLERS:
Main coolers—No. of sections..... 4
Auxiliary coolers—No. of sections..... 4
Air circulated, c.f.m.....
VALVE CONTROL EQUIPMENT.....
.....Liberty Electric Corp.
OIL CIRCUIT BREAKERS. General Electric Co.
Rating..300 to 600 amp., 7500 to 15,000 v.
Voltage .....2300 v. and 11,000 v.
DISCONNECTING SWITCHES .....
...Electrical Engineers Equipment Co.
FEEDER REACTORS .....
.....Metropolitan Device Corp.
Number .....6 53.3-kv.a., 3 40-kv.a.
Voltage....11,000, single-phase, 60 cycles
INSTRUMENT TRANSFORMERS .....
.....General Electric Co.
MOTORS AND CONTROL FOR STATION AUXILIARIES.....Allis-Chalmers Mfg. Co.
CONTROLLERS .....Cutler-Hammer Mfg. Co.
CONTROL TRANSFORMERS .....
.....Westinghouse Elec. & Mfg. Co.

METERS AND INSTRUMENTS

COMBUSTION CONTROL SYSTEM.....
.....Bailey Meter Co.
FLOW METERS.....Bailey Meter Co.
DRAFT GAGES.....Bailey Meter Co.
TEMPERATURE RECORDERS. Bailey Meter Co.
PANEL BOARDS, general..Bailey Meter Co.
PANEL BOARDS, control instruments....
.....Bailey Meter Co.
AUXILIARY GENERATOR Panels and Instruments....Carleton-Mace Engr. Corp
MAIN CONTROL Switchboard.....
.....General Electric Co.

Reminiscences of an Elevator Inspector

PART II.* DISCUSSION OF TROUBLES ENCOUNTERED WITH SEVERAL INSTALLATIONS OF AUTOMATIC ELECTRIC ELEVATORS. BY S. H. SAMUELS

AUTOMATIC elevators have troubles peculiarly their own. One installation in mind was built of a combination of parts from several elevator manufacturers, no doubt some of the parts were the "brain children" of the constructor. This installation had been in operation for a long time when suddenly it took a notion that it would not go to the top floor. Then, when this car was called or sent to the basement landing, it would overtravel and be stopped by lower limit switch.

As the basement landing was seldom used, both the hall and the car buttons were disconnected for this landing and correction attempted for the other trouble. Still the car would not proceed to the top landing. Cams made of ⅛-in. strap iron nailed to the wooden guide rails were located at each landing. The floor controller was on top of the car which successively engaged with these cams as the floors were passed. It appears that somebody had mistakenly kicked the engaging cam of this floor controller over, just one notch, while on top of the car. Had it been accidentally kicked in the opposite direction, the upper limit would have had to be depended upon to prevent the car from going into the overhead.

TROUBLE CAUSED BY FIRE IN WIRING

Fire, in another case, broke out in the entire winding behind the control board of an automatic elevator. Fortunately the entire fire was confined only to the wiring behind the board. Gear oil had dropped on the floor near the machine but the efficient work of the firemen prevented a spread of the fire. The slate panel was cracked from the cold chemical sprayed on the board and the control coils were destroyed. An entirely new control board was necessary before this elevator could be placed in running condition. Evidence, after the fire, showed the cause of the fire quite conclusively by tracing of the wiring behind the panel. Such a coincidence occurred that wires from both sides of one of the potential fuses were shorted out and rendered ineffective for their terminal wires had grounded on the frame of one of the control solenoids while the other potential fuse was wired up. It was also found that the wire direct to the motor (after the starting resistance had all been cut out of circuit) was grounded on the controller frame.

Taking all factors into consideration, it is assumed that by operating the car from one of the hall buttons half of the line voltage was immediately thrown on the motor. This was not sufficient to blow the main fuses or to overheat the wires, but current in this wire to ground caused an arc which started the insulation burning. The car evidently was proceeding to its called destination until the grounded wire was burnt apart for the car was found stuck between floors. Of course the insulation of the wires, when once afire, kept burning until put out or entirely consumed. This case emphasizes strongly the importance of not wiring fuses, and that all motor and control frames as well as conduit should be thoroughly grounded according to code requirements.

TROUBLES WITH INTERLOCKS

Electrical interlocks and their auxiliary equipment, such as contactors, emergency release and sequence relay, are a source of considerable trouble when they take a notion to get out of working order. Interlocks at the successive floors are connected in series and when a single lock gets out of order it is sometimes difficult to say just which one is giving the trouble, because all of the locks in that elevator shaft will be affected accordingly. The worries and difficulties in locating the trouble are about four times as great for each extra lock out of order at the same time. For this reason, the engineer should immediately discover and correct the ailment as it occurs and not resort to the misuse of the emergency release by plugging it with a piece of wood. Through the abuse of the emergency release device by "plugging," the very object of the interlocking of hatchway doors is defeated by rendering their interlocks ineffective.

Personally, the writer is much against having any type of emergency release device in the car and especially where it is convenient for the operator to use because of the universal abuse of its emergency possibilities. The writer does not know of a single case where this release has been legitimately used, for there are many methods by which the lowering or the raising of an elevator car for various purposes may be successfully accomplished without resorting to the emergency release device.

INTERLOCKS MUST BE KEPT IN GOOD CONDITION

Fire departments, however, insist upon an interlock release device in the car inasmuch as an elevator in a building is a very important exit in case of fire, when hoistway doors and their interlocks are likely to become inoperative. This viewpoint is sufficient to make the emergency release absolutely necessary in the car. It is therefore the duty of the engineer to maintain his interlocks in perfect working order at all times which will make it possible to keep an unbroken glass in the emergency release.

How much would fire alarm boxes be abused by the turning in of false alarms if the fire departments did not test out their alarm boxes periodically and immediately replace broken glasses in them after a legitimate alarm? The comparison is obvious.

Much of the interlock trouble can be traced directly to the habit of some operators of starting a car on the interlocks. The operator will have the controller handle full over and then close his door. In this way the car starts when contact in the lock is made, which is an

*The first article of this series appeared in the May 15 issue and the third and last will be published in the near future.

abuse of the lock. Such abuse is paid for in trouble for the engineer, for even though only a slight arc is formed between contacting surfaces, this arcing is destructive nevertheless. Repetition of starting the car on the interlocks roughens the contacting surfaces more. Contact made without current flowing is the ideal condition which will permit these contacts to perform the duties for which they were designed.

Sequence Relay Prevents Abuse of Interlocks

In connection with the installation of interlocks, the writer is in favor of the installation of a sequence relay for the reason that the above-outlined interlock abuse is the cause of endless worry for the engineer. When the engineer gets "stumped" as to the correct seat of the trouble or when he can ill afford the necessary time from his other urgent duties to effect permanent interlock repair, he resorts to the prior stated abuse of "plugging" the emergency release device until he "can get to it." Meanwhile the entire interlocking system is ineffective and may remain so for some time, according to the diligence of the engineer, only to be put out of commission again a short while later as a consequence of some other lock becoming troublesome. The sum and substance of this is that an interlocking system may be useless for more than half the time and all on account of the emergency release.

Had no such a device been in the car in the first place, then the interlock repair would have been accomplished when it occurred, in order that elevator service might be restored as soon as possible, unless for urgent reasons the engineer deemed it necessary to disconnect the operation of the system from the elevator control board or to short out the defective lock. Should a hatchway door accident then occur or approach occurrence, direct responsibility for it may be justly placed whereas, with the emergency release device in the car, other persons than the engineer might "plug" it and there would be difficulty in attaching responsibility.

Operation of Sequence Relay

Consideration, therefore, should be given to the sequence relay as a means of preventing interlock trouble at the source and the other almost criminal abuses as stated. This relay properly installed on the control board makes it imperative that the car controller is in the neutral position until interlock contact is made first. With some types of interlocks, the door must be fully closed and locked before contact is made, while, with other types of interlocks, contact is made when the door is 3 in. from full closure, arrangement being made in the lock design to prevent further opening of the door when within the 3-in. zone of closure.

Some engineers contend that the sequence relay will slow up elevator traffic. That this is a fallacy is witnessed by the fact that the same argument was made when the installation of interlocks for hatchway doors was first suggested as a safety measure. Those who have used interlocks with success for a long time on sizable installations realize their real worth as a humanitarian safeguard and know that this argument falls flat.

Current practice proves that even slightly better traffic regulation is possible with effective interlocks. The elevator operator has had to realize that he must make his landings the first time and without "jogging" his car in order to give the desired service under the apparent handicap he thought was given him with the installation of interlocks; consequently our operators become more skilled in their duties and power bills for elevator operation are appreciably cut, since the landing is made at the first attempt. The cost of electric power in starting an elevator is what runs up the electric power bills. Interlocks have helped to demonstrate that a good elevator operator will save more in power bills than the difference in wages of a cheap operator.

Apparently the handicap of the sequence relay which makes it necessary that contact must be made by virtue of the door being closed before the controller handle is moved from its neutral position is "only in the head" and falls by the wayside when safety benefits, immunity from interlock trouble, lower power bills and the development of efficient operators are taken into consideration as determining factors. With the sequence relay and interlocks, operators become accustomed to move the controller automatically at just the right instant when the door closes and efficient elevator operation becomes a regular matter with the spirit and courtesy that goes with it to present a business-like atmosphere.

Ice Jam Relief

EVEN though ice jams are not to be worried about for the next few months, it seems probable that next winter may see them accumulating to harrass the operators of water-power plants. Consideration of remedies may not, therefore, be amiss as a fore-arming against future difficulties. Anyway it's a cool subject for a hot summer day.

Seemingly it is useless to argue with an ice jam. Whether it be a big one which clogs a whole river or intake, or a little one which shuts off flow through a trash rack or water screen, only force will persuade it to let go. Blasting is certainly forceful, but may be attended with undesired results. Heat energy is the other forceful method and seems to be in the way of getting results.

Use of Thermit in Breaking Jams

In the Research Narratives of Engineering Foundation No. 138, Professor Howard T. Barnes of McGill University tells of success in the use of Thermit for breaking ice jams, by planting a charge in the jam and setting the Thermit to burning. This Thermit is a mixture of finely powdered aluminum and oxide of iron. When ignited, it burns, generating very high temperatures, producing liquid steel and giving off radiant heat rays that penetrate ice for many feet. Incidentally, the ice about the charge is melted, vaporized and converted so rapidly into steam, hydrogen and oxygen that a powerful explosion occurs.

Because of the explosion and the rotting and cracking of the ice by the radiant heat, the jam is crumbled so that water currents carry it away piecemeal.

As to results, in February, 1925, 250,000 t. of ice in the St. Lawrence River were sent on their way by three charges of 90 lb. each. A jam of 1,000,000 t. of ice at Ogdensburg, N. Y., was removed in 9 hr. by two 90-lb. charges. A mass at Morrisburg, Ont., 8500 sq. ft. and 9 ft. thick, was lifted off a shoal and broken up by one 90-lb. charge. At Franklin, Pa., a dry jam, 25 mi. long, was removed without damage in 10 days. Com-

pared to these, the usual jam around a power plant should be easy pickings.

Incidentally, Professor Barnes has been having a go at destroying icebergs and feels that they can be destroyed at moderate cost, thus removing a serious spring danger to shipping in the North Atlantic.

For rotting ice, sodium chloride, calcium chloride, calcium carbide, crude sulphuric or hydrochloric acid are effective, especially mixed with cinders, sand or gravel to draw the heat of the sun's rays.

Trash racks offer a different problem, for they become coated with frazil ice that closes the openings. Here Thermit treatment might not be desirable for the heat would melt or warp the bars and the ice body is not great enough to allow of buying the charge. The racks can be raised and cleaned but, meantime, trash may pass into the wheels.

Heating Racks by Electricity

In Norway and Sweden, and at Shawinigan Falls Plant, heating the racks by means of electric current has been used effectively. C. R. Reid, in a paper before the Engineering Institute of Canada, states that 140 to 425 watts per cubic foot of water per second will maintain a temperature sufficient to melt the ice. At Shawinigan, where there are 5 bays, each 12 ft. wide by 25 ft. 6 in. deep, connections are made so that one series circuit, 615 ft. long, covers 2½ bays. Screens are welded to and supported by steel angles which rest on oak blocks that serve as insulation.

Current at 135 v. and 30 cycles is taken from a 750-kv.a. transformer, 3680 amp. being required. Bars of the screens are 3½ by $\frac{5}{16}$ in., being connected 4 in parallel and 12 in series.

With 135 v., 227 w. are used per cubic foot of water per second but for severe conditions, higher voltage and wattage can be used by changing transformer taps.

Making an obdurate river thaw itself would seem to be poetic justice as well as good economics but Mr. Reid states that, if frazil ice is experienced more or less continuously, it would probably be better to make the racks of tubes and circulate warm water through them. Either way is an ingenious method of making the river cure its own fractiousness.

Provision now for next winter will be an antidote for the heat of summer and may avoid getting hot later over an ice jam.

Home-Made Torch for Ignition of Pulverized Coal

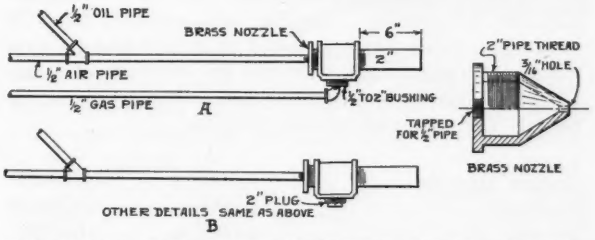
By V. E. Todd*

CONSTRUCTION work was completed last year, at the Sheboygan plant of Wisconsin Power & Light Co., changing two 500-hp. Stirling boilers from stoker firing to pulverized fuel. With the stokers, a continuous fire was maintained, once the boiler was started in operation. With the introduction of the pulverized fuel, however, it was necessary to secure ignition each time the boiler was placed in active service. Several methods were tried and found either impractical or uneconomical, until the oil torch shown here was developed and adapted to the conditions.

*Station Superintendent, Sheboygan Plant, Wisconsin Power & Light Co., Sheboygan, Wis.

Furnaces are of the well type with burners arranged to project the fuel stream vertically downward. The firing floor is approximately 12 ft. below the burners and two small round observation doors are set into furnace wall 3½ ft. above the floor. This made an ideal location at which to introduce an oil torch into the setting.

Accordingly, the necessary piping was run from an oil storage tank outside the building to a point conveniently near the boilers. Another line was run to the



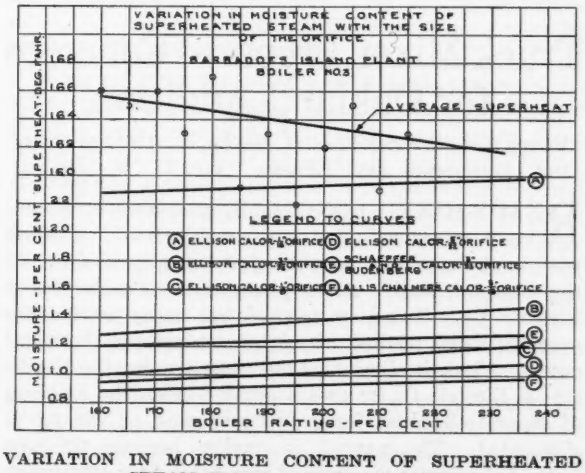
DETAILS OF FUEL OIL OR KEROSENE TORCH FOR PULVERIZED COAL IGNITION. A—FIRST CONSTRUCTION, USING CITY GAS. B—PRESENT CONSTRUCTION, IN WHICH GAS PIPE IS OMITTED

same location from the station air supply system. A third line from a nearby building was run in to supply gas from the local gas plant. A rubber hose was used to connect from the piping to the torch in order to make it flexible for use in both boilers.

Sketch A shows the construction of the torch as first used, sketch B as used when gas was found unnecessary. An oil-soaked piece of waste or rag is used to start the torch. Oil used is of the grade usually supplied to domestic oil burners; low grade kerosene is also satisfactory.

Dissociation of Steam in Superheaters

NUMEROUS FAILURES of different metals under superheated steam service have occurred from time to time. The cause of these failures is the inability


VARIATION IN MOISTURE CONTENT OF SUPERHEATED STEAM WITH THE SIZE OF THE ORIFICE
BARBADOES ISLAND PLANT
BOILER NO3
AVERAGE SUPERHEAT
LEGEND TO CURVES
A ELLISON CALOR-½"ORIFICE
B ELLISON CALOR-¾"ORIFICE
C ELLISON CALOR-⅝"ORIFICE
D ELLISON CALOR-¼"ORIFICE
SCHAEFFER & BUDENBERG CALOR-¾"ORIFICE
F ALLIS CHALMERS CALOR-¾"ORIFICE
MOISTURE - PER CENT SUPERHEAT-DEG FAHR
BOILER RATING - PER CENT

VARIATION IN MOISTURE CONTENT OF SUPERHEATED STEAM WITH SIZE OF ORIFICE

of certain metals to withstand more than a certain temperature. Several other theories have been advanced, one of which embodies permeation of the metal by a

gas, hydrogen, oxygen or carbon dioxide, being suggested as possible gaseous agents. The possible existence of hydrogen or oxygen in steam may be the result of dissociation of steam into its constituents. Another theory proposes the existence of moisture in superheated steam, the two possible causes being condensation and stratification while passing through the superheater.

Because of the importance of the subject, lack of definite information and existence of conflicting theories, the N. E. L. A. recently canvassed their entire membership for information. Replies were received from 30 companies, 25 of which reported that they had no data whatever to contribute. Various gas contents of steam as determined by one company shows the following, in pounds per thousand pound of steam:

	A	B
Carbon Dioxide	0.000013	0.000017
Hydrogen	0.000003	0.0000016
Oxygen	0.000105	0.000102

Tests made by another company of air from a condenser by four different methods shows that variation of hydrogen by volume in c.c. per liter is from 6.6 to 11 depending upon the method used in the analysis. These tests were made following four cases of failure of metal which showed unmistakable evidence of intercrystalline weakness. Three cases were of embrittled turbine blades and one was the case of a failure of a bronze bushing in a gate valve. In the case of the turbine blades, the blade as a whole was not brittle, but the exterior portions were unusually bad and immediately raised the question of permeation of the metal by gas.

Reports of tests to determine the moisture content of steam were also obtained. They show that the determination of the proper size and location of the orifice offers the most serious difficulty in this connection. The curves shown indicate the moisture in superheated steam from 16,800-sq. ft. boilers as found by various calorimeters and various sized orifices used on these calorimeters. Although the results vary considerably, attention is called to the fact that moisture is indicated in every case and in considerable quantity.

Truck Mixer Prepares Concrete for Oakland Addition

MOTOR TRUCK WITH SPECIAL MIXER ELIMINATES STORAGE, HANDLING AND ERRORS. BY C. W. GEIGER

READY-MIXED CONCRETE, prepared in a concrete mixer mounted on a motor truck, is being used in the construction work now being carried out at the Oakland, Calif., steam plant of the Pacific Gas & Electric Co. This new method has many advantages over the usual method of mixing concrete in the usual mixer. First, it eliminates the necessity for the Pacific Gas & Electric Co. to own a mixer. Also, the building of separate bunkers for gravel and sand on the job is eliminated. The payroll is smaller because the new method eliminates the crew of men behind the stationary mixer and also dispenses with the engineer. The mess and nuisance of sidewalk obstructions is also eliminated. Time is saved, not only in preparatory work, but also in the actual pouring of concrete.

This concrete mixer is an "open top" supermixer mounted on the chassis of a motor truck. An entire fleet of these combined mixers and motor trucks is operated by the Rhodes-Jamieson Co. in Oakland. Under the bunker at the Rhodes-Jamieson Co. the prescribed batch of crushed rock, sand and cement is dumped into the "open top" body. Also, the exact amount of water is run into the separate tank on the body. Then the driver takes this dry load batch to the job. The same power that drives the truck now is applied to mix the pre-measured load of cement, aggregates and water. In a few minutes, the driver mixes and quickly dumps a

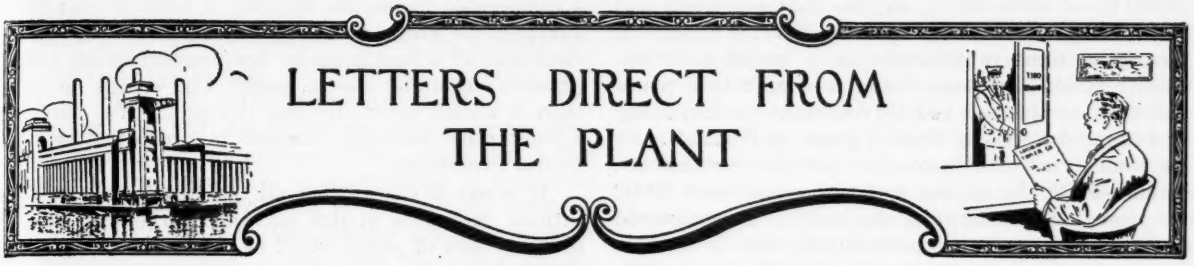
TRUCK MIXER, OPERATED FROM TRUCK ENGINE, POURING CONCRETE AT OAKLAND

perfect batch, and drives back to the materials yard for another load.

By this method a quality mix is guaranteed as all the batching and measuring of aggregates and tanking of required water is done at the material yard by an experienced concrete man. Thus there is small chance for error or change from specifications. The aggregates are transported to the job dry; there is no worry over precrystallization or separation of water from cement, as in the case of concrete that is mixed and then hauled to the job.

PETITIONS of the Iowa Railway & Light Corp., Toledo, Iowa, and the Cedar Falls Municipal Electric Co. for authority to construct and operate electric transmission lines over about the same territory in the Cedar Falls district have been filed with the Black Hawk county, Iowa, board of supervisors.

A GOOD ENGINEER is known by the condition of his machinery. Blame yourself once in a while, not always the machine; certain causes always produce certain effects.



Economies of Combining Industrial Power Plants

POSSIBILITIES of combining industrial power plants, as covered by Mr. Gaylord's interesting discussion in the May 15 issue, page 551, have been read with an interest abetted by some considerable experience along this line and with a keen appreciation of the problems, benefits and difficulties involved. The larger industries, especially those growing rapidly, have the same problems within themselves and in the course of expansion, many of our older companies have been through it. Slowly but surely, industry has swung away from the one time universal direct engine drive and has adopted motor drive, with all units or departments served by a single isolated power house. In general, the combining of power plants of several individual industries offers the same problems and has the same advantages. The design of a central station is a complicated matter extending over a period of many months and the proper layout of a heat balance in a large industry is just as difficult and complicated. Mr. Gaylord has told the whole story in the statement that "Each must be studied as a separate problem."

Experience is a great thing, yet the individual experience of one man taken alone could not serve a fraction of the possible conditions. First, one must know all the conditions of power and steam demands; second, he must have a thorough knowledge of the construction, application and performance of the available equipment; third, he must have much common sense. To be successful, an industrial layout must be simple and direct. Usually the master mechanic or maintenance man can be trusted to have an abundant supply of common sense and if, after the various types of equipment, their advantages and disadvantages are explained to him, he does not, thinking independently, reach the same conclusions as the designing engineer, it's a good time to go over the layout and see whether you may not have slipped up somewhere.

In the end, however, the engineering feature is the least important one. The purpose of business is to make money and all forms of business, even all forms of honest business, do not make it the same way. There is the small business with little capital for improvements pushed by competition to cut production costs; unless conditions are unusually bad, a capable operating engineer is their best bet. Then there is the rapidly expanding industry that is making money and having little difficulty in raising capital; as a rule, competition and production costs are not troubling it greatly and unless conditions are bad, investment in power plant equipment is not attractive because the same investment put into the business will pay a bigger return. This company needs a competent consulting engineer and a low-priced flexible layout that will permit expansion and refinements, as competition and the money market demand it.

In somewhat the same class is the company that is making money but not expanding. For business reasons, it is desirable to bring its plants to a high state of perfection and refinement, without too close a check on the financial returns on the investment. Such outlay is, in reality, a continuation of the surplus fund in a more desirable business form.

Also, there is the old conservative business, well established, financially sound, making a substantial return, not contemplating expansion, finding any construction of this kind desirable if it will pay a larger return than it will obtain elsewhere on an investment offering the same security.

From Mr. Gaylord's discussion, I would place the company he mentions in the fourth class; that is, an investment of $224,000 paying 19.5 per cent is more attractive than the smaller investment of $58,250 paying 42.2 per cent. The last $166,750 investment pays about 11.5 per cent and unless this could be equaled elsewhere, the higher investment would be preferable.

For the reason that unseen conditions, those that can be determined only from a first-hand and complete investigation largely influence decisions, we must assume that Mr. Gaylord's solution is the proper one, although there are a number of questions that arise in my mind and I am sure that they will arise in the minds of other engineers with experience along the same line, that bear discussion.

Judging from the present equipment, evidently the matter of standby capacity is not of major importance and has been dispensed with except, possibly, in plant C where reserve boiler capacity is installed. Under Mr. Gaylord's Scheme 1, plant A is not considered and the arrangement suggested means simply that B abandon public utility power and install its own engine. This leaves B out of the picture and the installation of a 500-kw. turbine in plant C is in effect nothing but plant D switching power supplies. As arranged, plant C installs a turbine, stands all the expense, and sells plant D power at practically cost, benefiting only through the economy of combining the load. The total investment of $38,000 saves $20,957.50, of which plant C, which stood 92 per cent of the investment and has three times that tied up in the plant, gets but $6,887.70, or about 33 per cent, hardly consistent with the pains taken to apportion properly the investment under Scheme 2.

As the three 200-hp. boilers in plant C are designed for 225 per cent rating, at 30 lb. per b.hp., or over

40,000 lb. of steam per hr. and the combined steam load of B, C and D is 37,500 lb. per hr., it seems to me that the logical thing to do would be to install a 750-kw. bleeder turbine in plant C and to supply both power and steam to plants B and D from plant C, abandoning or keeping for standby the old plants at B and D. At the same price of $70 per kw. used for the 500-kw. turbine, $3000 for piping and wiring to D and $8000 for piping and wiring to B, the total investment would be but $63,000 and the operation of plant B could be dispensed with, saving directly $14,337 in supplies, repairs, labor and interest on the additional investment of $20,250, as well as about $2500 in coal, figuring only on the increase in evaporation from 7.6 to 8.4 lb. of water per lb. of coal. This gives a total saving of some $41,500 over present operation and pays a return of about 65 per cent on the investment of $63,500. This is directly comparable to Mr. Gaylord's saving of $24,610 with an investment of $58,250 under Scheme 1.

In the foregoing paragraphs, I have made no attempt to follow through the exact steam and power demands of the combined plants. At peaks, the combined load of the three plants is 37,500 lb. per hr. and the electric load 1050 kw., which would give a water rate of about 36 lb. per kw-hr. for a balanced condition. Just what relation would hold at lower loads, I have not attempted to determine and if the steam to the condenser is excessive, it might be advisable to install superheaters in the boilers and cut down the engine and turbine water rates to give a better balance.

Perhaps the cheapest thing to do would be to install a 1000-kw. turbine, take in plant A and keep the boiler there as a standby to take peak load. Allowing $2000 additional for a high-pressure steam line from plant C to plant A, the total investment in this case, using the same costs, would be:

Turbine	$70,000
Piping and wiring	17,000
	$87,000

Another possibility and, I feel, without going into the matter any more deeply, the most desirable, would be to install two 500-hp. bleeder turbines and one 200-hp. boiler, similar to the ones already installed in plant C and take on plant A. This would mean an investment of about:

Turbine	$70,000
Piping and wiring	15,000
Boiler (200 × $75)	15,000
	$100,000

but would mean the concentration of all power in one plant, decreasing expense of plant A a direct cut of at least $8400, without considering fuel, giving a total saving over present operation of at least $49,900, or a return of almost 50 per cent on the investment.

Offhand, I do not see how Mr. Gaylord could possibly justify either his Scheme 1 or Scheme 2. Certainly 1200 b.hp. of modern boilers for a total maximum demand of 44,500 lb. of steam per hour is excessive. If some condition of load demands it, plant A should be left out of the scheme entirely, as the additional expense of taking care of it is not warranted.

As a rule, I do not feel, from experience, that a complicated theoretical division of costs is workable. Probably the most satisfactory way is to reach an agreement and set a fixed price for low-pressure steam, high-pressure steam and electric power, high enough so that there is a small profit, dividing this profit, after leaving a substantial operating surplus, in proportion to the several investments.

If power is charged for all the steam going to the turbine, regardless of that extracted for process work, the large user of power would be discriminated against, while if bled steam is sold on a strictly thermal basis, as Mr. Gaylord has done, the large user of process steam would get the short end, because, for practical purposes, especially if there is a considerable distance to transmit it, 15 lb. wet steam is not worth 97 per cent as much as 200 lb. steam throttled to 15 lb., even though it be sold on a B.t.u. basis. Again, the steam user would be losing all advantage of the by-product power and the power user would be getting it for nothing.

Of course it might be said that 1000 B.t.u. is 1000 B.t.u. to the steam user and he would have to pay full price if the turbine were not there. On the other hand, the thermal efficiency of the turbine would be much lower if the exhaust steam were not used, so that the only fair way is to divide the savings between the two users. To my way of thinking, Mr. Gaylord's division of steam between the two is based on the same reasoning that he used in proportioning his investment and operating costs between plants C and D in his Scheme 1. If plant C is instrumental in cutting the costs of plant D $0.009 per kw. and $0.24 per 1000 lb., it seems only reasonable that plant C should share in the profits, at least to a certain extent.

Another point that I am sure would cause disagreement is his division of investment in Scheme 2. Under this scheme, the boiler and engine room would cost $209,000 made up as follows:

Boiler, stokers and chimney	$60,000
Turbine	40,000
Piping	12,000
Switchboard and wiring	7,000
Building	30,000
Old plant C power plant	60,000
	$209,000

In the distribution of this $209,000 plant, C pays but $53,200, a reduction of its investment $60,000 — $53,200 or $6800, while plant A pays $28,800 and scraps a $15,000 power house, plant B pays $64,220 and scraps a $20,000 boiler room, and plant D pays $77,780 and scraps a $6000 boiler room. Furthermore, Scheme 2 could not be carried out, because it is only logical to assume that plant D would object to investing $77,780 to save $16,992.96 a year, when an investment of $3000 under Scheme 1 would save it $14,069.80.

Perhaps my reasoning is not good; perhaps if it is an actual case, conditions are such that the arrangements he suggests are the only ones possible and again it may simply be a hypothetical case, which Mr. Gaylord arranged to illustrate the possibility of saving and used to this end without attempting to determine the most economical arrangement.

St. Petersburg, Fla. PAUL F. ROGERS.

Reactive Component in A. C. Circuits

In the May 15 issue, V. E. Johnson presented Part IV of his article, "The Reactive Component in A.C. Circuits." While this covers the subject in considerable detail, it is the opinion of the writer that a few additional remarks would be of assistance to readers in making practical application of the methods outlined. The method given for obtaining the power factor in a three-phase balanced circuit from the ratio of two single-phase meter readings or the ratio of the two readings of the separate elements of a polyphase meter involves the availability of a table of trigonometric functions or a table of ratios as given in the article. The need of either of the foregoing references may be dispensed with for this purpose by using the following formula:

$$\text{Power Factor} = 50\sqrt{\frac{(1+a)^3}{1+a^3}}$$

Where "a" is the ratio of W_1 to W_2 (W_1/W_2), W_1 being less than W_2, taking account of the proper sign whether plus (+) if both elements when operating singly rotate or deflect in the same direction or minus (—) if the slower element moves in the reverse direction. The equation just given is rarely, if ever referred to, and its absence from text books and reference handbooks seems all the more strange, when it is appreciated that the more or less universal use of the slide rule and the comparative simplicity in extracting the square root of the quantity under the radical makes its use well worth considering, to say nothing of the absolute freedom from reference to any table and the ease with which the expression can be memorized. For instance, to cite a few examples of its application, assume a power factor of 100 per cent; since W_1 and W_2 are equal then "a" $= W_1/W_2 = 1$ and we get by substituting in the formula

$$\text{Power factor} = 50\sqrt{\frac{(1+1)^3}{1+1}} = 50\sqrt{\frac{8}{2}} = 100$$

Assuming W_1 as + 1 and W_2 as + 2 we get

$$\text{Power factor} = 50\sqrt{\frac{(1+0.5)^3}{1+0.5^3}} = 50\sqrt{\frac{3.375}{1.125}} = 86.6$$

If W_1 is zero we get

$$\text{Power factor} = 50\sqrt{\frac{(1+0)^3}{1+0}} = 50$$

If W_1 is negative, that is if it is in a reverse direction to W_2, we get a negative (—) ratio, assuming "a" as —0.5 the formula becomes

$$\text{Power factor} = 50\sqrt{\frac{[1+(-0.5)]^3}{1+(-0.5)^3}} = 50\sqrt{\frac{0.125}{0.875}} = 18.9$$

It is also possible to obtain reactive kv.a. readings by means of standard meters on three phase or two phase circuits. For a two-phase circuit an accurate method is that indicated in Fig. 1. The diagram is self-explanatory and it may be noted that the current element is combined with a voltage element which at 100 per cent power factor gives a combined effect at an angle of 90 deg., hence no resultant effect tends to move the meter element since the current value is zero when the voltage is maximum or vice versa. For any other power factor there will be a resultant effect due to the change in the angular relations of the current in one phase to the voltage in the other. Single phase indicating wattmeters or watthour meters or a two-element polyphase meter may be used for this measurement.

For a three-phase system standard single phase indicating or polyphase two-element meters may be used

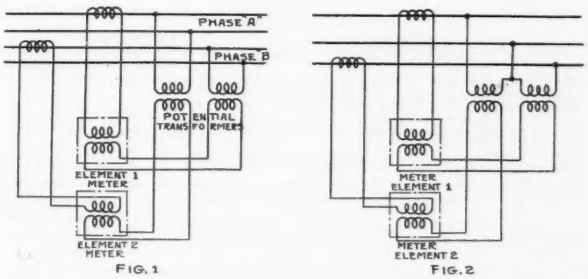


FIG. 1. METHOD OF OBTAINING REACTIVE KV.A. READINGS BY MEANS OF STANDARD METERS ON A TWO-PHASE SYSTEM

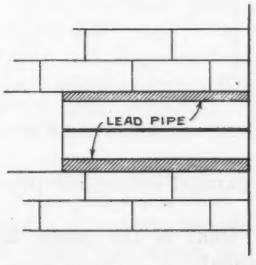
FIG. 2. METHOD OF OBTAINING REACTIVE KV.A. READINGS ON A THREE-PHASE SYSTEM

connected as shown in Fig. 2. To obtain the true reactive kv.a. reading, the indicated result must be multiplied by $\sqrt{3} \div 2$, or 0.866. While this method has the objection of making a constant necessary in actual application it obviates the necessity of the special voltage transformers required for actual kv.a. meters or the use of a special dial train in a watthour meter or special scale on an indicating meter.

Brooklyn, N. Y. C. O. von Dannenberg.

Lead Pipes Serve as Anchorage

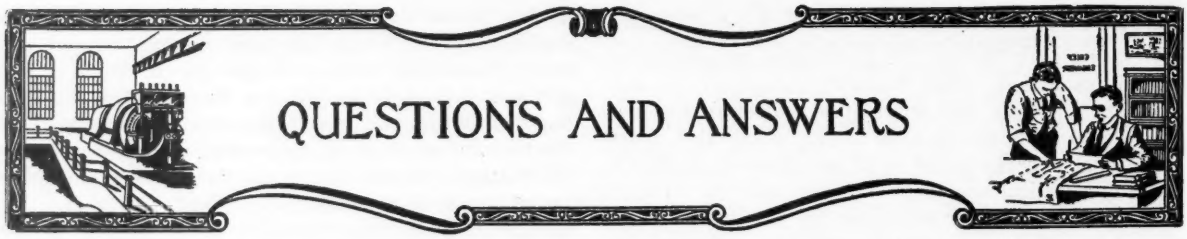
Shown in illustration, is a little kink used with success on the Coast. Some holes had been drilled in a brick wall and it turned out that the holes were a little



SPLIT LEAD PIPE PERMITS USE OF UNDERSIZED EXPANSION BOLTS

too large in diameter for the expansion bolt casings on hand. The difficulty was overcome by using short pieces of heavy lead pipe cut into halves and set inside the drilled holes.

Toronto, Canada. John Thorn.



Transformer Connections

WILL YOU KINDLY explain, with the aid of vector diagrams, the following questions concerning the transformer connections shown in Fig. 1?

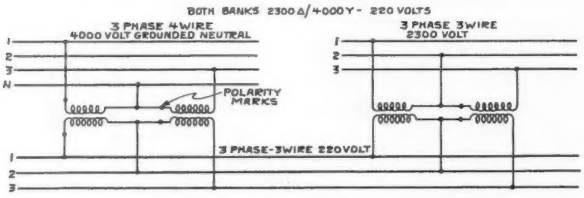

BOTH BANKS 2300 Δ/4000 Y - 220 VOLTS
3 PHASE 4 WIRE
4000 VOLT GROUNDED NEUTRAL
3 PHASE 3 WIRE
2300 VOLT
POLARITY MARKS
3 PHASE-3 WIRE 220 VOLT

FIG. 1. TRANSFORMERS CONNECTED IN STRAIGHT OPEN Y

1. Is this parallel connection practical for temporary service?

2. If not, what is the phase difference between transformer banks?

3. Again, if this connection is incorrect, could they be connected to operate in parallel, and what would be the actual result of attempting such a connection as shown? J. U.

A. Two transformers connected in straight open Y as illustrated in Fig. 2, will give unbalanced voltages and unsymmetrical phase relations, as shown in the voltage diagram. To make this operative, one of the secondaries must be reversed, as in Fig. 3.

The open delta connection in Fig. 4 is correct, a symmetrical voltage diagram being obtained as shown.

In order that these two banks may be paralleled, it is necessary that the voltage diagrams be similar in form and position. In other words, the triangles in Fig. 3 and Fig. 5 must have their corresponding sides in parallel. This, in turn, is determined by the nature of the tie between the 4000-v. and 2300-v. primaries. In the absence of information on this point, the following cases may be assumed:

a. That the 4000-v. bus and the 2300-v. bus are served from separate generators. In that case, the angular relation is of no significance, because the rotors

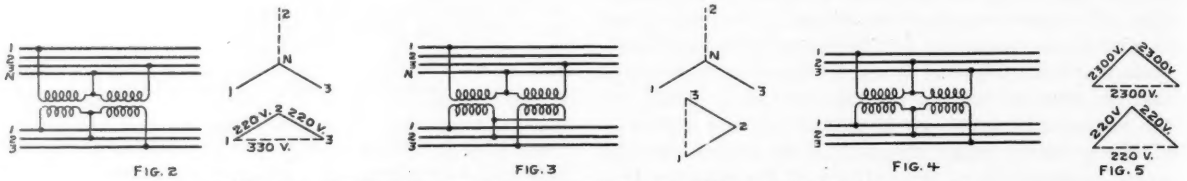


FIG. 2 FIG. 3 FIG. 4 FIG. 5

FIGS. 2-5. TRANSFORMER CONNECTIONS AND THEIR VECTOR RELATIONS

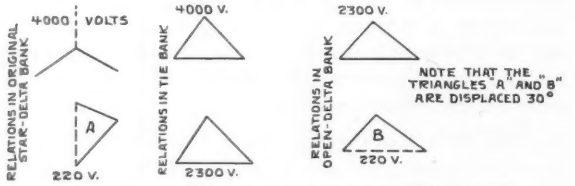


FIG. 6. VECTOR RELATIONS OF VOLTAGES

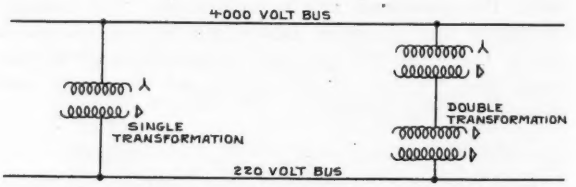


FIG. 8. ONE LINE DIAGRAM OF TRANSFORMER CONNECTIONS

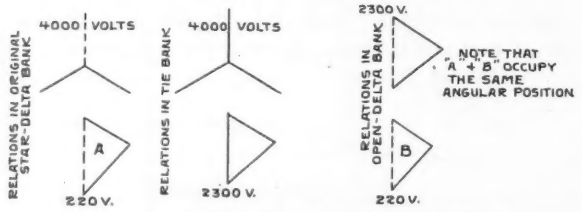


FIG. 7. VECTOR RELATIONS OF VOLTAGES

will, upon synchronizing, assume the proper positions; therefore the connection shown in Fig. 3 will be operative. It must, however, be borne in mind that the tie between two generating systems must be of sufficient capacity to keep them in step. The smaller of the two banks would have to be not less than 25 per cent of the rating of the smaller generator or connected group and may have to be considerably larger.

b. That the 2300-v. bus is fed from the 4000-v. bus through a delta-delta bank. In that case, the primary and secondary phase relations would be those shown in Fig. 6. The phase displacement is 30 deg., and the system is inoperative. The same would be true if a star-star bank were used.

c. That the 2300-v. bus is fed from the 4000-v. bus through a star-delta bank. The primary and secondary phase relations would be those in Fig. 7. The phase displacement would be zero and the bank would operate.

The amount of load that could be carried would depend upon the relative impedances of the transformers.

By reducing the connections to a "one-line diagram," as in Fig. 8, it will be seen that parallel operation is required between a "one-transformation" and a "double-transformation" group. With ordinary units, having impedances approximately equal, the "double-transformation" group would shirk the load.

Condenser Operation

PLEASE give me the answers to the following questions:

1. If you have a barometric jet condenser with a good vacuum and you should put vacuum gages every two feet from the sealing water to the top, would they all read alike?

2. If you were running a condenser with only one pump and you wanted to get 29 in. of vacuum, what trouble would you have with the pump?

3. What is the difference in construction between a dry air pump and a wet air pump? N. A. B.

A. All vacuum gages would read alike under the circumstances stated since they are all connected to the same gaseous or vapor space. If the space were in whole or in part occupied by a liquid, the heads at various heights of liquid would correspondingly modify the readings on gages placed at those heights.

2. There should be no trouble with your pump if it is of large enough capacity to secure a vacuum of 29 in. If, however, this is not true and you wished to increase the vacuum, it would be necessary to increase the amount of cooling water used.

3. Wet vacuum pumps remove both condensate and air together from condensers in a common cylinder; dry vacuum pumps are compounded, one end of the cylinder comprises the first stage, the second stage being at the opposite end of the cylinder. Dry vacuum pumps remove only the air and non-condensible gases; the water is handled separately.

Leaky Stop Valve Causes Corrosion

CAN YOU TELL us what causes some of the rivet heads in the upper part of the steam space of our 150-hp. h.r.t. boilers to be eaten away or corroded? The worst looking rivets are in the collar of the safety valve. These rivets are eaten away about $\frac{1}{16}$ in. Our boilers are only about one year old. There are two boilers and each has been in service about six months.

Around the upper manhole and flange for the steam outlet pipe, the rivets appear to be in fairly good condition. Some of the rivets on the end braces in the upper shell show that they were eaten away also. Could there be something wrong with the metal in the rivets?

All the water space in the boiler shows a coating of lime. The boilers are used mostly for heating and laundry service. All condensation is returned to the boiler by a pump after passing through an open feedwater heater. Our make-up water, so far, has been hard water. J. C.

A. For the service you state, you are probably using the two boilers alternately. If then, as we believe, your stop valve leaks into the dead boiler, the steam would condense and cause corrosion. This steam would not under these circumstances mix with the boiler water hence would not be influenced by the alkaline condition which may exist in that water.

Continuous reuse of the boiler feedwater has a tendency to acidify it, hence the conditions enumerated, together with the fact that corrosion is more prevalent where exposure to air exists rather than where parts are submerged in water, indicate a situation which would be such as quickly to promote corrosive action if the stop valve leaks.

Use of Steam Tables

HOW CAN I find the total heat in one pound of steam whose temperature is 397 deg. F. and whose pressure is 180 lb. per sq. in. absolute? J. J.

A. Tables of Properties of Steam such as published by Marks and Davis and by Peabody or abridged tables found in engineer's handbooks such as Kent's or Marks' may be consulted with reference to problems such as given above. If you do not have any of these books they will very likely be found in your Public Library and the librarian will be glad to assist you.

Consulting Marks & Davis' tables No. 2, we find for 180 lb. pressure, the corresponding temperature for dry and saturated steam is 373.1 deg. F. Since the temperature you give is 397 deg., the steam must be superheated 397 — 373.1 = 23.9 deg. Consulting table 3 which gives the properties of superheated steam, therefore, we find that for 20 deg. superheat the total heat of the steam is 1209.4 B.t.u. and that of 30 deg. superheat is 1215.5.

Interpolating between these figures we find the difference in total heat to be 1215.5 — 1209.4 = 6.1 and the amount of superheat 23.9 deg. given is 3.9 more than 20, therefore, if we multiply 6.1 by 0.39 we find the amount of heat to be added to the total heat for 20 deg. superheat to be 2.38, i. e., $6.1 \times 0.39 = 2.38$ and $1209.4 + 2.38 = 1211.78$ which is the total heat in B.t.u. of 1 lb. steam at 180 lb. absolute pressure and 397 deg. temperature.

Gage Glass Connections Should Be Straight and Simple

ERRATIC action in our gage glass has caused periodical blowing out of soft plugs. For a time the water will move slowly up and down in the glass when suddenly all movement will stop and a short time later the water drop out of sight entirely. What causes this action? E. T. P.

A. We believe your trouble is caused by pockets formed in your steam pipe connection. Cases similar to this have been made to operate temporarily by jarring the pipe system when the water line ceased moving slightly. This would cause the water line to drop suddenly, indicating that a pocket had been dislodged by the jar.

Check your connections and lines. Connections should be as simple and direct as possible and there should be no pockets. All lines should drain in the proper direction.

EDITORIAL COMMENT

Interconnection

Complicated networks of colored lines on sketchy maps, startling newspaper headlines on the order of "Back Bay Radio Power from Chicago," essays on the power trust, superpower, Giant Power and a host of popular words, phrases and pictures are, in the popular mind, usually the vital factors in the much-abused word, interconnection.

The mere fact that development of long distance transmission made possible interconnections that were not feasible before apparently leads directly to the popular conclusion that long distance transmission and interconnection are synonymous. The announcement some time ago, that Boston and Chicago were linked together electrically must have been a source of satisfaction to the radio enthusiasts of both cities.

If radio power could be supplied to Boston from Chicago generating stations, no doubt the process could be reversed and power supplied to Chicago from Boston. It is satisfying to know that should the operators of the Commonwealth Edison system decide to take a holiday it would be necessary only to throw a switch and let the Boston Edison stations carry the load.

As a matter of fact, interconnection is not long distance transmission, as was pointed out forcefully by George N. Tidd at the N. E. L. A. Convention, when he said, "For any long distance, say considerably in excess of 100 miles, the cheapest way of transmitting coal-generated kilowatt-hours is in freight cars and in the original form." Of course, Mr. Tidd, as president of the American Gas & Electric Co., probably speaks from hearsay and not with the authority of the newspaper feature writers.

When first started, interconnection had for its object the tying together of many small isolated plants into a network or group of efficient generating stations. The second phase of interconnection, developed more recently, is the tying together of systems normally independent.

Utilization of the more efficient plants and of hydro capacity during certain periods, reduction of reserve or standby capacity and economical construction of stations beyond that justified by the immediate load are some of the commonly mentioned advantages. Mr. Tidd is of the opinion that the combined weight of all the advantages mentioned will be less than the weight of that due to the possibility of rendering mutual aid. This is often sufficient to cause a favorable decision which is not justified from an engineering or dollars and cents standpoint.

Interconnection is not a mere fad. It is of material value to the utilities and to the public. It is of vital importance in solving the problem of power distribution and, in the agricultural districts, will be of assistance to rural electrification. Its importance, although limited in area, is not primarily due to long distance transmission of power but rather to the insurance of uninterrupted and continuous economical service that long distance transmission of power permits the participating utilities to offer the public.

Modernization of Hydro-Electric Plants

Importance of remodeling various types of steam power plants, refrigerating plants and oil engine plants has been discussed frequently in the technical press. Remodeling of hydro-electric plants, however, to take advantage of the progress in this field, has not received the amount of attention it deserves. Yet the principles governing such remodeling work are much the same in all cases, whether the raw material from which power is made happens to be coal, oil or water.

These principles are primarily economic, rather than engineering. They involve primarily the two factors of depreciation and obsolescence. In short, as pointed out recently in these columns, a point is reached in the life of any equipment at which it will probably pay to replace it with a newer and better machine, not because it is old but because the improved performance of the new device will save at least as much as, and possibly more than, the cost of keeping the old one in operation.

Just why hydro-electric plants, in general, have been apparently neglected in applying the above principles is not quite clear. This neglect is especially apparent in industrial installations, which, as a rule, are much older than public utility plants. So many people have the feeling that the water is free, anyway, that this may be the answer. What does it matter if some of it is wasted? Then, too, the average overall efficiency of a hydro plant—energy efficiency, not necessarily dollar efficiency—is usually higher than that of other types. Hence, if it drops 10 per cent, it is still pretty good. Finally, many owners of hydro plants let them run down to such a point that they do not feel like throwing good money after bad, whereas, if they but knew it, a comparatively small expenditure might make such plants into paying propositions.

These and other problems involved in the modernizing of hydro-electric plants are discussed by Clayton N. Ward elsewhere in this issue. He shows how the work was carried out at several plants owned by public utility companies, in which various factors made modernization desirable. In one case, mechanical failure of a turbine case, besides the wearing out of the units with great loss in efficiency, was an important consideration. In other cases, tests on the old units showed clearly that their best days were over.

This was, of course, no reflection on their manu-

facturers or on the way in which they had been installed and operated. It is simply an illustration of the fact that progress in design and performance is extremely rapid and that machinery does wear out, even the best of it. In the above cases, the old machinery was replaced by new units of the latest types. The time will come when these units, too, will have served to the full and will have to retire to make way for equipment that incorporates still further improvements. They will be "the old units that were installed 25 yr. ago, 'way back in 1927."

Books Should Be Reliable Instruments

Books should be as instruments in the hands of an engineer, therefore they should be designed and constructed to fill a specific need just as an instrument is so designed and constructed.

Many textbooks and hand-books now coming from the press, while supposedly discussing topics with which the book is concerned with sufficient fullness to make possible the use of the data and principles involved, frequently present only one or two sides of the question but discuss a single phase, which may be a hobby of the author, in extreme detail. Should the writer of a book on a general subject indulge his hobby in a reference book?

Would not the value of a textbook be increased and its influence in developing judgment enhanced if, after presenting the underlying principles involved, all practical methods of application would be at least enumerated and their several limits, advantages and disadvantages tabulated, if not discussed, and references made so as to enable the reader to acquire, when desired, detail data from original sources? Tabulation permits of rapid survey over a large field; it stimulates analysis and comparison and establishes judgment.

One recently published textbook devotes half of its pages to material taken bodily from A. S. M. E. codes which are available to all who wish to consult them. Would not the employment of this space for analyses, critical discussions and summaries have been more effective? Likewise, a recently issued "handbook" contains a large amount of material apparently condensed from manufacturers' catalogs and numerous reprints of articles written, it is true, on various topics with which the subject is concerned but written in the form of magazine articles rather than modified for handbook use. Should not condensation of detail but inclusion of all forms and an ample index characterize all handbooks?

Engineering textbooks should be so written that the student will turn to them for reference after his graduation. They should, therefore, be so arranged that it is unnecessary to reread early chapters in order to discover the meaning of the factors of an equation given later in the book. Not only is it desirable to have the values of factors tabulated under practically every equation but the units in which such factors are taken should also be stated. Likewise units in which quantities are taken in tables or diagrams should be stated definitely. Handbooks, being obviously intended for ready reference, should be particularly clear in presentation of formulas, tables and charts.

Loose and incorrect statements abound in many of our hurriedly written "handbooks" and textbooks. When one reads that "valves, such as intake and exhaust valves, are entirely eliminated," since there is no modification, the reader is justified in understanding that this refers to all two-stroke cycle gas or oil engines.

Another gem comes from a textbook written by an engineering instructor for his students. This enlightens us with the statement that "The Curtis steam turbine is interesting due to the fact of being a vertical turbine."

Such incorrect and misleading statements nullify the assumed authority of the authors in the mind of the engineer who is well versed in the subjects discussed but what of the young engineer groping for a guide?

We do not need more engineering books nearly so much as we need more convenient engineering books, for which there is always considerable demand.

Does a Glue Factory Increase Your Power Costs?

Let us suppose that you, the reader, have recently been appointed chief engineer of a power plant and that, after two or three months on the job, you are just beginning to know your way about and get the situation sized up so that you can handle it. You have discovered that the condenser serving the main turbine functions properly for a while after cleaning but soon after that begins to give trouble. You have also discovered that in spite of the fact that you have a good water treatment system, all is not well in the boilers. Condenser circulating water and the boiler feedwater makeup come from the nearby river.

Would you be inclined to suspect that the cause of your trouble lay in the pollution of the river, upstream from your plant, by waste products dumped into it from industrial processes? Suppose you found that this condition prevailed, due to the presence of a glue factory or a steel mill upstream. Would you know just how to attack the problem?

How would you determine what constituents in the water were undesirable? Where on the river would you take your water samples and how often? How would you analyze them? Could you do this yourself or would they have to be analyzed by a chemist? How would you interpret the results of your analyses?

If you have a pretty good idea as to how the foregoing questions should be answered, it will be interesting to turn to page 711 and see how your ideas check up with analysis of conditions and their treatment, as given for a particular river by D. C. Carmichael. If you can't answer any or all of them, you have a pleasant surprise in store, for Mr. Carmichael explains clearly and concisely just how definite problems were solved.

They are problems that are encountered by the largest central station and the smallest industrial plant. Not long ago, for example, the editor visited a great public utility plant which had to clean condensers every day, because of the discharge from a glue factory on the river a mile upstream. Thus the manufacture of glue actually did increase the cost of operating the central station. The real cause of the trouble was a mile away from the power plant itself.

Thus, when condenser and feedwater troubles are encountered, pollution of the water supply source should be considered and, if such pollution is found, the data presented in the above article show one way to attack the problem.

With the N.E.L.A. at Atlantic City

FIFTY-FIRST CONVENTION ATTTENDED BY POWER AND LIGHT EXECUTIVES AND ENGINEERS FROM ALL OVER THE COUNTRY

ATTENDED BY over ten thousand members and guests, with an important array of noted speakers from many fields and with a brilliant social program coupled with a week of fair weather, the 51st convention of the National Electric Light Association held at Atlantic City June 4-8, was an unparalleled success. Under the able guidance of President H. T. Sands, the convention activities proceeded with clockwork precision and with unusual efficiency.

Following the usual preliminaries, the convention was formally opened on Tuesday morning, June 5, with the address of President Sands, at the first general session, and from that time on the entire week was taken up by business sessions. In accordance with the custom adhered to during the past few years, most of the sessions were general sessions of interest to all; in fact, with the exception of those held on Tuesday afternoon, no simultaneous sessions were held. On Tuesday afternoon, four simultaneous sessions were held, i.e., the Public Relations Section, Engineering Section, the Accounting Section and the Commercial Section. On the remaining days, general sessions were held both morning and afternoon. Wednesday night, as usual, was given over to the public policy meeting.

Social entertainment was not lacking. Accustomed to doing things in a big way, the entertainment provided at the N. E. L. A. conventions by the entertainment committee is always of the highest caliber and looked forward to by all who attend the conventions. This year Rolfe's Orchestra of New York furnished the music. With the exception of Wednesday night, which was devoted to the public policy meeting, there was dancing in the great ballroom on Young's Million Dollar Pier every night until 12 o'clock. The speeches and reports presented at the public policy session were interspersed with selections by Rolfe's Orchestra and solos by Richard Crooks, tenor, and a Metropolitan Opera star. This session was broadcast throughout the country by courtesy of the National Broadcasting Co.

WARNED AGAINST EFFECTS OF UNFAIR LEGISLATION

While a spirit of optimism pervaded the convention, there was not lacking a sense of the danger which might lurk in unfair legislation and other restraining measures sought after by politicians. The association does not fear any fair inquiry into the electric light and power industry and in his presidential address, H. T. Sands invited a most searching and complete inquiry by the Federal Trade Commission. The utilities, he said, are in the vanguard of American business, are proud of their record in the past and do not fear the proceedings of the present. In his address, he gave the lie to insinua-

YOUNG'S MILLION DOLLAR PIER, ATLANTIC CITY, WAS THE SCENE OF N. E. L. A. ACTIVITIES

tions that the industry has fostered propaganda among students in the schools and stated bluntly that it is an insult to American intelligence to believe that the utility companies would undertake such a plan.

Invite Investigation by Federal Trade Commission

To remove any element of doubt which may exist in the mind of the public through misleading statements by politicians and newspapers, the association welcomes the inquiry of the Federal Trade Commission and has thrown open to the Commission every record in its possession. Every publication, every address delivered, every news release made has been made available to members of the Commission. Over 2500 separate exhibits have already been introduced and made part of the record and accumulation still goes on.

It is true, said Mr. Sands, under the direction of the State Committees of Public Utility Information, pamphlets dealing with electric light and power, gas, telephones and street railways have been published and furnished for use in the public schools. The material contained in publications constitutes nothing more than everyday fact, yet judging from some newspaper accounts, one would think that the utilities, in some mysterious manner, have forced innocent school officials to compel their students to learn falsehoods from textbooks composed of propaganda, or else that there has been a conspiracy between utility companies and school teachers to pervert the youthful mind.

Of late, said Mr. Sands, there has been some public criticism of the activities of the association which discloses a gross lack of understanding. Certain portions of the press have carried statements to the effect that the annual budget of the association, amounting to approximately $1,444,000, has been expended wholly for the purposes of propaganda and that this expenditure constitutes a burden on the consumer of electric service which he should not be asked to bear.

Such a statement completely ignores the many other activities of the association. The total annual cost of carrying out all of the activities of the association, including the refunds to the Geographic Divisions, amounts to approximately 16/1000 of a mill per kilowatt-hour sold to the public or between 4 and 5 cents per customer per year.

Program Included Many Forceful Speakers

Other speakers at the first general session were Managing Director Paul S. Clapp, J. F. Owens, chairman of the Public Relations Committee; H. P. Davis, chairman of the board of the National Broadcasting Co.; Howard K. Mohr, chairman of the Membership Committee; Treasurer P. S. Young; A. W. Thompson, president of the U. G. I. Co., and R. F. Pack.

Mr. Clapp in a forceful address recounted the developments in the industry, told of the work of the headquarters staff and gave a complete picture of the activities in which the industry was concerned.

Mr. Davis predicted talking movies for the home as well as facsimile transmission and many other radio developments. Even power by radio is a possibility, said Mr. Davis. While these are all valuable, perhaps the greatest benefit that may accrue to light and power companies from radio is the improvement of our knowledge of electrical phenomena.

Three Million Dollars to Be Spent for Research

At the session of the Engineering Section, Alex D. Bailey of the Commonwealth Edison Co. presented an address on "Organizing the Industry's Engineering Research." Mr. Bailey advocated an intensive research program for the electrical industry and called attention to the expenditure by the American Railway Association of $2,000,000 in a single year in research work, study and experiment on air brake equipment alone costing about $250,000 this year. In 1921, said Mr. Bailey, 578 industrial companies of the United States maintained research departments. Today double that number are operating them. It was gratifying, therefore, in view of Mr. Bailey's figures and facts, to learn that, through co-operative efforts of the electrical industry, $3,000,000 will be spent for research during the next ten years. For each year a sum of $300,000 has been made available. This announcement was made by R. F. Pack at one of the general sessions.

PRESTON S. ARKWRIGHT
Photo by Blank-Stoller, Inc.

Other speakers at the Engineering session were E. C. Stone, chairman of the section, H. S. Bennion, director of engineering, and W. E. Mitchell, vice president of the Georgia Power Co.

Major Bennion outlined the activities of the engineering national section and told of the co-operative work with related bodies. Co-operative effort, he said, benefits all—no one loses by it. A case in point was the work of the Inductive Co-ordination Committee. The telephone companies, said Mr. Bennion, have welcomed the formation of this committee. They hoped for such action on the part of the N. E. L. A. long before it was effected and have appreciated very clearly for a long time that in a field so technical and intangible real progress could be made only through co-operative effort.

Mr. Mitchell gave the executive point of view in engineering work and urged the importance of the management function. He emphasized the need for young engineers to build systems with a management perspective in mind, so that their systems might meet anticipated service needs most economically.

E. C. Stone, in his report on the work of the Engineering section, spoke on engineering planning and dealt at length with the complete meaning of economy in system planning. He made the point that the engineer has a responsibility second to none in the industry and must measure up to the new economic conditions faced by the industry.

One of the most notable speakers at the General session on Wednesday morning was Samuel Vauclain, president of the Baldwin Locomotive Works. He related some of the history on which future prosperity will have to be built and pointed out that as far back as 1890 he specified individual electric drive throughout the Baldwin Locomotive Works.

Oswald W. Knauth, vice president, R. H. Macy &

Co., Inc., at this same session recounted some of the fundamentals of merchandising and suggested that it might be to the advantage of the utilities to confine their activities to the generation and sale of power and delegate the merchandising of electrical appliances to those who are experts in that field, that is, the established merchants. The necessity for sound merchandising is far greater today than 25 yr. ago. There are more good merchants in the field and competition is infinitely keener.

The Electric Utility and the Public was the subject of an address by H. G. Wells, president of the National Association of Railroad and Utilities Commissioners. He defended the utilities against some accusations but at the same time warned of impending trouble if certain practices are not avoided. For example, he said that the majority of the industry should exercise moral suasion on the minority to prevent bad practices.

The final paper at this session was by Dr. W. R. Whitney, director of the Research Laboratory of the General Electric Co. Mr. Whitney spoke on electrical research and progress and stated that progress increases as the nth power of the number of investigations in progress at a given time. He referred briefly to some of the new theories of radiation and light production.

At the Public Policy Committee session, which was a notable feature on Wednesday evening, the Puget Sound Power and Light Co. of Seattle was awarded the Charles A. Coffin Prize, and R. H. Ballard presented the annual report of the Public Policy Committee. The Coffin Foundation gold medal is awarded annually by the General Electric Co. for outstanding achievements in the electrical field. A statement was issued in which it was decided that the N. E. L. A. will continue to make available to the public the facts and figures on the progress and development of the industry. This resolution was accepted and was considered to be the sense of the convention.

Another speaker at the Public Policy meeting was Melvin A. Traylor, president of the First National Bank of Chicago.

Water Power Development Slowing Up

Of the various committee reports presented at the convention one of the most interesting was that presented by Paul A. Schoellkopf, chairman of the Water Power Development Committee. He pointed out that we are facing a slowing up in hydro-electric development. Two factors are principally responsible for this: 1. The remarkable reductions in steam power costs in the past 5 years have made many water power projects economically unattractive today that looked attractive 5 yr. ago. 2. Political controversies and restrictive state laws have made it impossible for the time being to develop most of the larger and most feasible water power projects.

At the present time, of the 59,000,000 water horsepower available in the United States, analysis shows that 9,600,000 hp. or 16 per cent is developed, 6,000,000 hp. or 10 per cent will probably be developed in the near future, 12,000,000 hp. or 20 per cent, which is economically feasible, is being held up by political controversies or restrictive state laws, and the balance, 31,400,000 hp. or 54 per cent probably cannot be profitably developed under present economic conditions.

In the field of farm electrification, it was brought out, rapid progress is being made. The report of the Rural Electric Service Committee showed that more than 400,000 farms in the United States now use electricity. Many experimental enterprises are under way in this field.

P. S. Arkwright Elected President

On Friday, June 8, the convention came to a close with the election of officers for the coming year. Preston S. Arkwright, president of the Georgia Power Co. of Atlanta, was elected president. Mr. Arkwright has been a notable figure through the country in traction, light and power utilities.

Matthew S. Sloan, president of the Brooklyn Edison Co., was elected first vice president. W. A. Jones of Henry L. Doherty & Co., New York, second vice president, and J. F. Owens, vice president and general manager of the Oklahoma Gas & Electric Co., third vice president, and Arthur W. Thompson, president of the U. G. I. Co., Philadelphia, fourth vice president.

Percy S. Young, vice president of the Public Service Corporation of New Jersey, was re-elected treasurer.

Paul S. Clapp remains as managing director and A. Jackson Marshall was re-elected secretary.

It was voted to return to Atlantic City for next year's convention.

Construction Begins for First Unit at Ohio River Station

For the Southern Indiana Gas & Electric Co. at Evansville, Ind., the Commonwealth Power Corp. of Jackson, Mich., is designing a new power plant to be known as the Ohio River Station. Much of the equipment for this plant has been purchased and excavation was begun on June 1. The plant is expected to be in operation by July, 1929. The ultimate capacity for which the plant is designed is 100,000 kw. For the first unit, a 12,500-kw. Allis-Chalmers turbine-generator has been purchased. It is designed to use steam at 400 lb. pressure, 725 deg. F. total temperature.

Steam will be bled from the turbine at three points, two for feedwater heating and the third for evaporator service. A 7500-kw. Allis-Chalmers turbine-generator will be moved to the new plant from the present Division St. plant, where it was temporarily installed.

Boiler room equipment will consist of two Walsh & Weidner cross-drum boilers of 1152-hp. capacity each, with Elesco interdeck superheaters and Foster 8640-sq. ft. economizers. These boilers will be fired by Westinghouse, 35-tuyere, 12-retort stokers, air being supplied by American Blower Co. fans driven by two constant speed motors. The smaller and lower speed fan motor will be used for ordinary ratings and the larger and higher speed motor for peak load conditions.

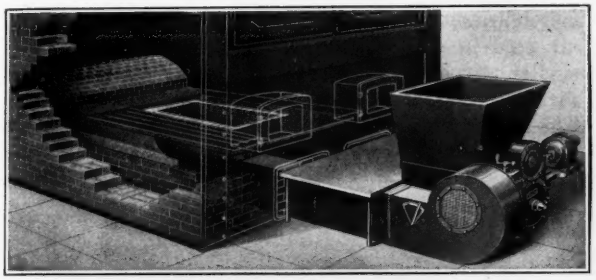
Griscom-Russell heaters, evaporators and air coolers will be used and Allis-Chalmers 15,000-sq. ft. condenser and auxiliaries have been purchased. Circulating water will be taken from the Ohio River; the river level variation amounts to about 50 ft. and the circulating pumps are to be designed with a shut-off head varying from 21 to 44 ft. The comparatively cheap coal precludes the use of air preheaters.

Combustioneer, Small Underfeed Stoker

DEMAND FOR an automatic coal burning device which would efficiently burn the cheaper grades of coal, both for heating and power purposes, has resulted in the development of a new automatic stoker, shown herewith, of immediate interest to plant managers, building owners, architects, contractors, engineers and building superintendents.

This device has been named the Combustioneer and is manufactured by Combustioneer, Inc., 570 W. Randolph St., Chicago, Ill. It is designed to feed coal automatically to the fire bed by the underfeed principle and to distribute it evenly over the entire bed.

Another feature is an adjustable air control to provide for variations in quality of coal and changes in



SMALL UNDERFEED STOKER WITH ADJUSTABLE AIR CONTROL

load. The gearless final drive is designed to be silent in operation, with bronze worm gear to eliminate friction. The final drive is through an all-steel overrunning clutch, operated through a bronze connecting rod and an over-sized eccentric. The coal feeding worm is semi-steel, connected to the drive by a universal coupling, protected against damage by a safety shearing pin. Interchangeable sectional tuyeres are provided.

Reading Electric Meters Over Telephone Circuits

FOR THE PURPOSE of obtaining readings of meters and instruments in all parts of the power system, an automatic telemetering device has recently been placed on the market by the General Electric Co. which indicates or records all the readings on a single receiving apparatus located at some central point.

This telemetering system operates over a single pair of wires, the receiver being actuated by impulses sent out by relays associated with the outlying meters. Since the readings are transmitted by impulses, ordinary variations in line wire resistance or battery voltages have no effect on the accuracy of the telemetering. Carrier current channels may be used to transmit the readings and in cases telephone circuits may be employed, without impairing communication in any way. Where a large number of intermittent readings from a particular station are required, standard supervisory equipment is utilized for selecting the various substation circuits and for connecting them to the common transmitting equipment.

The telemeter proper, located at the load dispatcher's headquarters, is simply an accurate speedometer calibrated in terms of the speed of the rotating meters at the sending end. It consists essentially of a motor connected by a spring coupling and gearing to a permanent magnet. The motor is allowed to make one revolution for each impulse received. This is transferred to the permanent magnet by means of a flexible spring coupling and gearing. Hence the magnet also makes a definite portion of a revolution for each impulse received. The dragging effect of the revolving magnet upon a disc, to which the dial hand or recording pen

AUTOMATIC TELEMETERING EQUIPMENT. LEFT—TRANSMITTING APPARATUS AT OUTLYING STATION. RIGHT—RECEIVING APPARATUS

is attached, translates the impulses into readings proportional to the indication of the outlying meter.

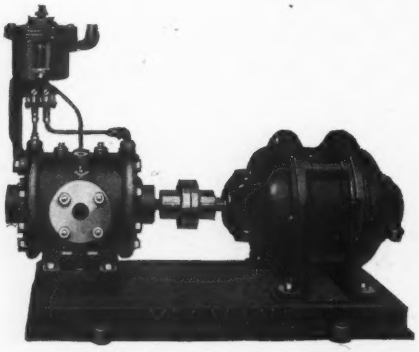
Important readings such as voltages, amperes, kilowatts, reactive kilovolt-amperes and frequency, may be transmitted in this manner from all parts of the system. The dispatcher may have either visual or recording equipment for receiving them. When kilowatts are transmitted, each impulse represents a definite number of kilowatt-hours. The telemetering device may therefore operate a demand meter or register kilowatt-hours on a dial. Kilowatts from several remote points may be totalized on one receiving meter. With the present widespread interchange of power resulting from high tension interconnection, this information serves as a valuable aid to the dispatcher in economically regulating the system.

One of these systems has recently been installed on the property of the Montaup Electric Co. This power system has three double-circuit interconnections with an adjacent power network, the tie-ins being at widely separated points. Kilowatts are totalized at each of the three points and transmitted to the dispatcher's office over leased telephone wires. The dispatcher has a

visual indication of the totalized kilowatts from two of the stations on one receiver, and visual indication from the third station on a second receiving instrument. A third receiver gives a visual and recorded reading of the combined total. Provision is also made to give the dispatcher an alarm when the totalized reading reaches a predetermined maximum value. He is provided with demand meter readings as well as readings of totalized kilowatt hours. Extensive use is made of the opportunity afforded by this type of equipment to obtain demand meter readings and kilowatt-hour readings at the various stations throughout the system.

Rotary High-Speed Air Compressors

ADAPTED TO ALL types of air compressor service for pressures up to 50 lb. per sq. in. gage, for small quantities of air and especially designed for use with the Shone pneumatic sewage ejector, the rotary, high-speed



MOTOR-DRIVEN ROTARY AIR COMPRESSOR FOR PRESSURES UP TO 50 LB.

air compressor shown in the accompanying illustration has recently been placed on the market. The compressor is of the multi-vane type, designed to produce steady non-pulsating flow of air and the arrangement is such that there is no actual contact between the vanes and the interior of the casing. Roller bearings support the rotor to minimize friction losses and to maintain perfect alinement.

These compressors are built without stuffing-boxes, a seal being obtained around the shaft by a special type of metal packing rings. On the suction of the compressor, a simple muffler is installed to insure quiet operation. Casing is of cast iron, as is also the rotor which is poured on the shaft to insure against slipping. Vanes are of spring steel ground to dimensions.

Compressors are built in water-cooled types for high pressures and in air-cooled types for intermediate service and low pressures. Automatic water control valve can be furnished. In the water-cooled type, a centrifugal, cooling-water, circulating pump can be supplied, mounted on an extension of the rotor shaft for use with a gravity cooling tank or hopper. Standard machines, however, are supplied for circulating water from city supply and without the circulating pump.

On each compressor is an automatic oil economizer, designed to provide lubrication of all parts of the compressor during operation and to shut off the flow of oil automatically as soon as the machine shuts down.

Compressors and their driving units, which are direct connected in all cases to eliminate belts and gears, are mounted on a cast-iron base. The compressors can be supplied for pressures up to 50 lb. gage and speeds up to 1750 r.p.m. and, at present, are being developed for capacities up to 150 c.f.m. actual delivery of free air. They are manufactured by Yeomans Bros. Co., 1432 Dayton St., Chicago, Ill.

Unit Air Filter Uses Cellulose Filter Medium

FOLLOWING a long period of research, the National Air Filter Co., Chicago, has announced the commercialization of a new unit type air filter for cleaning air used in cooling large motors, compressed air and similar purposes. A blanket of cellulose material is the dirt collecting medium, an entirely new idea in this field. The new material, developed by the Kimberly-Clark Co. especially for the new filter, consists of a mat of many

UNITS EMPLOYING AIRMAT GO TOGETHER LIKE SECTIONAL BOOKCASES

layers of fine cellulose fibers. It will be known commercially as Airmat.

Single units consist of a sheet metal box 12 in. high, 24 in. wide and 24 in. long with a filtering capacity of 1000 cu. ft. of air per minute. These units can be used singly or placed in multiple installations of any capacity, much after the fashion of sectional bookcases.

Filtering material, resembling a very light, fluffy white blanket, is carried between two frames of coarse wire screen hinged together on one side and opening out like a book. These frames are the proper size to receive a single sheet of the Airmat 24 in. square.

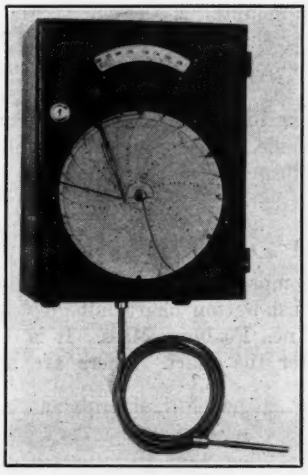
Each unit contains four such frames, which form a set of staggered partitions, being placed in cross section like a letter W, so that 16 sq. ft. of filter surface is

contained in each individual unit. A spring clip holds the frames in position and they may be easily removed from the unit, opened up and a fresh blanket of Airmat inserted in a few seconds without disturbing the unit itself.

In addition to the 1000-cu. ft. unit type, a second type of continuous filter has also been developed for applying Airmat where automatically-renewed, "constant effect" filters are needed. In this type, the filter blanket is fed onto a drum from a continuous roll. As the exposed part of the blanket gradually becomes choked with dirt, the loss of head in the air flow automatically actuates the drum and fresh filter blanket is fed into place as the dirty portion is removed.

Recorder and Thermometer Controller in One Case

DESIGNED to combine in one case the features of a rugged recorder and a thermometer controller, the equipment shown here is now offered by The Bristol Co., Waterbury, Conn. It consists of a single pen recording system with controller system and scale mounted



RECORDING PEN AND MOVING CONTACT OF CONTROLLER ARE ACTUATED BY SEPARATE PRESSURE ELEMENTS IN THE COMBINED INSTRUMENT

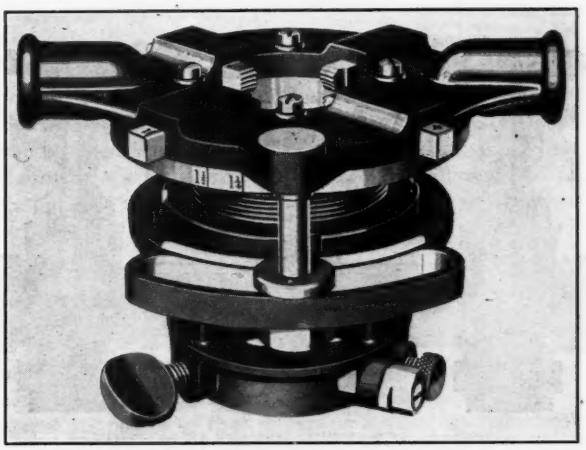
directly above it. Recording pen and moving contact of the controller are each actuated by separate pressure elements, which are exactly alike in construction. These elements are connected through one capillary tube to the sensitive bulb; and arranged in this way, it is stated, the record is not impaired by retarding effect of the controllers and the recorder draws a true record both above and below the control point. This recorder controller is arranged for a contact capacity of 1000 w. by equipping it with self-contained automatic switches.

To use, it is only necessary to set the control to the desired temperature by moving an index pointer over a scale to the exact degree to be controlled. Zero adjusters are provided for both recorder and controller pressure elements. Large current carrying capacity of this controller makes it possible to adapt the instrument to many control applications without the use of relays.

Beaver Adjustable Die Stocks

TWO NEW self-contained and adjustable 1 to 2-in. die stocks, the No. 11 Beaver plain tool and No. 11A Beaver ratchet are announced by the Borden Co., Warren, Ohio. Number 11 Beaver supersedes the old No. 25 plain tool, and No. 11A supersedes the old No. 26 ratchet. The new die stocks are designed to be lighter in weight, easier working, simpler in construction and lower in price than the old tools which they supersede and as durable as the previous models.

In these new Beavers, one set of dies is quickly set to thread 1, 1¼, 1½ or 2-in. without changing dies. The dies cannot be lost or mislaid because they are always in the tool ready to use. Dies are quickly adjusted to thread under or over standard without affecting the length of the thread. No special dies are needed for



NEW DIE STOCK THREADS PIPE FROM 1-IN. TO 2-IN. WITHOUT REMOVING DIES

brass pipe. The threading dies in these new tools are made of high-grade alloy steel, specially hardened and tempered. Die head and threaded barrel are two separate parts so that when repairs are required only one part need be bought. The work holder, or pipe gripping device is of new design to center the pipe accurately.

SHAWINIGAN WATER & POWER CO., Shawinigan Falls, Que., has secured a lease of water power rights on the St. Maurice River from the Government of Quebec, for a period of 75 yr. The sites are estimated to be capable of developing about 650,000 hp. and extend downstream from present developments of the company at Shawinigan Falls, Grand Mere and LaGabelle. There are three principal localities for construction of generating stations: at Blanc Rapids, 172,000 hp.; Secours Rapids, 85,000 hp.; Allard Rapids, 50,000 hp., and the leasing company plans early operation at these points. In accordance with terms of the agreement, actual construction must begin not later than July, 1930, and a development of at least 100,000 hp. completed by July 1, 1933, in which an amount of at least $10,000,000 is to be expended. The power company is to pay an annual rental of $25,005, and in addition, a yearly royalty of $1.00 per hp. developed.

Bypass Fitting Simplifies Piping

IN THE DEVICE illustrated herewith, the arrangement of three valves in a single fitting to be used for the bypassing of traps or other apparatus, results in compactness, simple piping arrangement and the elimination of many joints which might be the source of

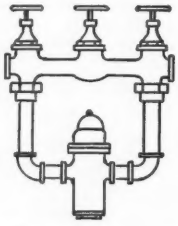


FIG. 1. BYPASS FOR A STRAINER

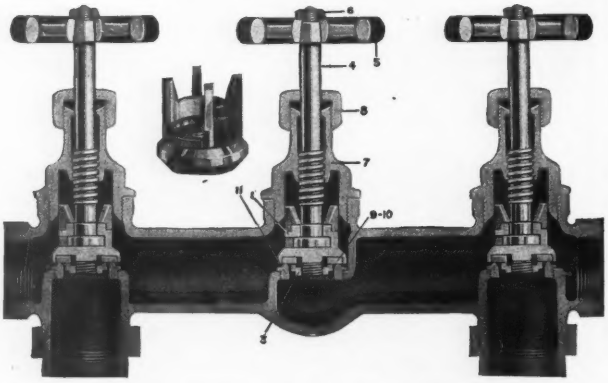
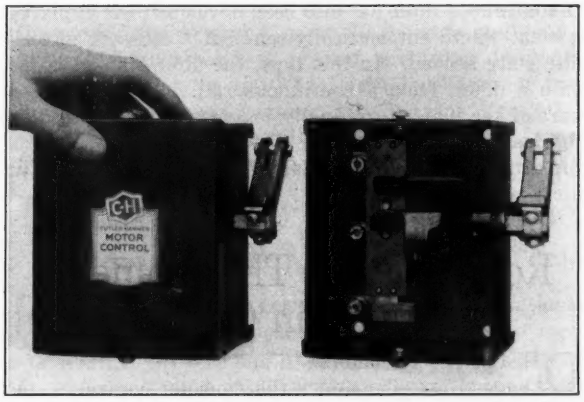


FIG. 2. SCHAEFER BYPASS IN SECTION

leakage. The valves are fitted with renewable seats and discs of composition or of metal and the bypass is made up in either standard or extra heavy pattern. Simplicity of piping for bypassing a strainer is indicated by the line drawing. The device is made by Frank H. Schaefer Co., of Philadelphia, Pa.

Lever-Operated Master Switch Has Many Uses

DESIGNED ESPECIALLY for splined shaft or shipper rod operation, a new switch recently placed on the market by the Cutler-Hammer Mfg. Co., of Milwaukee, should find application in many lines. It is intended for use as a pilot circuit control device on lathes, textile machinery and other equipment where starting and stopping of the machine is governed by a splined shaft, shipper rod or similar device. Low voltage protection is one of the important features. Should the motor stop, due to low voltage or for any other reason, it will not re-start until the switch has been operated again. Accidents and damage to machines caused by unexpected re-starts are thus eliminated. Some of the other outstanding features are: non-stubbing contacts; shear pin to protect mechanism; few parts and simple construction; the operating lever can be placed in any one of four operating positions, 90 deg. apart, to suit any installation requirement; long, steel-to-bronze main bearing with oil hole; small size; fully enclosed in heavy steel case; cover can be removed by loosening only two screws. The switch is designed especially for three-wire control but can also be used

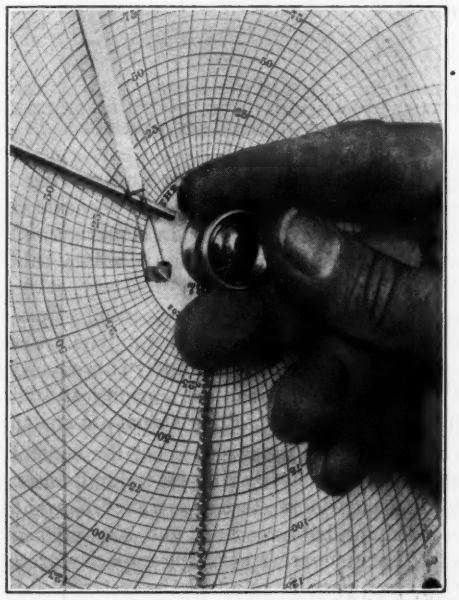


CUTLER-HAMMER SWITCH, SHOWING INTERNAL CONSTRUCTION

for two-wire control on pilot circuits up to 550 v. This switch may be mounted at the end of the machine, the splined shaft or shipper rod running the length of the machine. In operation, moving the switch to the "on" position starts the motor, the same as pressing the "on" button in the ordinary pushbutton station. Throwing the switch in the opposite direction stops the motor. Mechanism is protected against damage by a shear pin.

Push-Button Chart Hub

IN THE accompanying illustration is shown the new Foxboro push-button chart hub, developed by The Foxboro Co., Inc., Foxboro, Mass. It is designed accurately to center the chart. There are no threads or

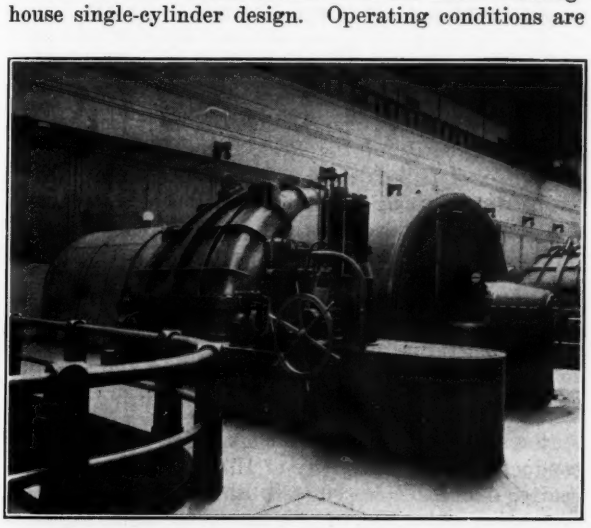


PRESSURE ON BUTTON OF HUB RELEASES CHART

complicated mechanisms. A slight push of the tension head snaps it into position where it grips the chart securely in place. Twisting the head to left or right turns the chart to the correct time adjustment. It is not necessary to remove the chart holder. The hub is designed to be easily detached. With the holder between the first and second fingers, the operator has simply to press the button under his thumb and the chart is released, without tugging or jerking of the chart hub, nor strain on the clock spindle.

Duquesne Light Co. Installs Two New Turbine-Generators

As part of its program of expansion, the Duquesne Light Co. of Pittsburgh has recently installed two 41,250-kw. Westinghouse turbine-generator units in its Colfax Station. Each turbine is of the latest Westinghouse single-cylinder design. Operating conditions are



ONE OF THE NEW 41,250-KW. UNITS AT COLFAX

260 lb. gage at the throttle, 214 deg. F. superheat and back pressure of 1 in. of mercury absolute. The turbine is designed for bleeding at four points for feedwater heating. One of the outstanding features of the design of this turbine is the governor, which is of a type only recently applied to units of such size, although it has been used in connection with 3600-r.p.m. turbines of modern size for a number of years. The Colfax turbines operate at 1800 r.p.m.

News Notes

Power Plant Equipment Co. announces that it has moved to larger quarters at 1737 Walnut St., Kansas City, Mo. It was formerly located in the Coca Cola Bldg.

General Refractories Co., Philadelphia, Pa., announces that R. P. Heuer is resigning as instructor in Chemical Engineering at the University of Pennsylvania to become Director of Research of the company. His headquarters will be in Philadelphia.

James Cleary has been appointed as general sales manager of Combustion Engineering Corp. His early experience was secured with Westinghouse Church Kerr Co. as erecting and operating engineer in various parts of the United States, and in England as erecting and operating engineer on the Metropolitan Railway Co.'s plant, London, the Mersey Railway plant, Liverpool, and the Clyde Valley Electric Power Co.'s plant, Glasgow. On returning to this country, Mr. Cleary became associated with the Westinghouse Machine Co. Mr. Cleary served as chief machinist and warrant officer in the Spanish American War. and during the World War was in charge of the steam equipment of the "Old Hickory" government plant. Since associating himself with Combustion Engineering Corp., in 1921, Mr. Cleary has been district manager of the Philadelphia and Detroit offices and for the past 2 yr. assistant general sales manager.

Jos. Dixon Crucible Co., Jersey City, N. J., announces that its Chicago sales office is now located at 2003 Builders Bldg., Wacker Drive and LaSalle St., Chicago, Ill.

In the item on page 654 of the June 1 issue, relating to the appointment of representatives by The Wellman-Seaver-Morgan Co., Cleveland, Ohio, the statement should have been made that these companies are appointed as sales distributors for the Wellman line of valves only and not as general representatives for other products of the company.

Because of recent improvements and added attachments, the Ideal portable electric combination blower and suction devices, described on page 216 of the February 1, 1928, issue, have been adapted to many difficult cleaning tasks, it is announced. Improvements in the construction of the motor itself have been made to increase its power so that it can be applied to industrial cleaning. One model for supplying either a cold or a hot blast of air has been developed. Various suction cleaning attachments can be provided for use with the units and they can now be adapted, by still other attachments, to spraying of paint, insecticide, varnish, lacquer oil and other liquids. All this equipment can be supplied by the maker of the blower, Ideal Commutator Dresser Co., Sycamore, Ill.

Pennsylvania Power & Light Co., Allentown, Pa., has applied to the State Public Service Commission for authority to acquire and consolidate 35 light and power companies operating in different parts of the state.

Conditions of award of the Samuel Wylie Miller Medal by the American Welding Society for achievement in the welding field have been broadened by the board of trustees to cover other activities as well as the presentation of papers. Revised conditions are as follows:

1. The medal may be awarded annually for any meritorious achievement which, in the judgment of the board of trustees, has contributed conspicuously to the advancement of the art of gas fusion welding and cutting or the art of electric arc fusion welding and cutting.

2. The award for any calendar year shall be announced and the medal, together with a suitable certificate, presented at an annual meeting or a fall meeting of the society as the board of trustees may elect.

Electric Bond & Share Co., 2 Rector St., New York City, is reported to be planning the construction

of a hydro-electric power plant at Agos Falls, on the Agos River, Lanao, Philippine Islands, where a head of about 2300 ft. is available. The initial plant will be equipped for an output of approximately 25,000 kw., with transmission system extending to different parts of the district. Lyman B. Hammond, vice president of the company, has recently returned from an inspection trip of the locality.

Wm. G. Christy, for the past 2 yr. executive secretary of the Citizens' Smoke Abatement League of St. Louis, Mo., has tendered his resignation, to take effect July 1, it has been announced by League headquarters. The board of directors accepted the resignation and, in appreciation of his services, granted Mr. Christy a month's vacation with full pay. For the present, he will continue to maintain his offices as mechanical engineer in the Railway Exchange Bldg., St. Louis.

Grafton Power Co., a subsidiary of New England Power Assn., has petitioned to build plants at 15-Mile Falls on the Connecticut River, estimated to cost $40,000,000. In 15 mi. of river there is 300 ft. fall. One dam will be 150 ft. high. Preliminary work of surveys and acquiring property at sites of plants and for flowage has been under way for over a year.

Niagara, Lockport & Ontario Power Co. has been granted an order affirming the legality of condemnation proceedings for lands needed in the Lighthouse Hill development. There is still a question of title to some land at the site of the plant which is on appeal. Some $100,000 has already been expended on excavation and concrete work but activity was halted by the legal proceedings. The plant will be 10,000 hp. with dam 482 ft. long, 50 ft. high and impounding 135,000,000 cu. ft. of water in a 175-a. reservoir.

Virginia-Carolina Power Co., operated by the Virginia Electric & Power Co., Electric Building, Richmond, Va., has made application to the Federal Power Commission for permission to construct and operate a hydro-electric power plant on the Roanoke River, Brunswick County, Va., and Warren County, N. C. The project will include a power dam and 20-mile artificial lake, to provide a storage capacity of close to 500,000,000 cu. ft. The plant will be equipped for an initial output of 50,000 hp. and an extensive transmission system constructed for connection with present lines.

Frederick C. Rockwell, Carmel, Calif., has applied to the state division of water rights for a development near Mina on the Eel River, to develop 24,400 hp. and supply 200 cu. ft. per sec. to Eureka, Petaluma and adjacent communities. Cost of the power project was estimated at $1,500,000.

Hartford Electric Light Co., Hartford, Conn., has contracted with the Connecticut Co. for power supply for its traction system, comprising about 3500 kw. and supplementing an existing agreement for about 1500 kw. The Hartford Co. will install additional equipment costing about $200,000 in its power plant on Commerce Street. All requirements will be furnished from this plant and the station at Dutch Point will be held in reserve for emergency service.

Texas Utilities Co., Plainview, Texas, has concluded negotiations for a merger with the Community Power & Light Co., operating in the same vicinity, with executive offices in the Planters Building, St. Louis, Mo. The consolidated organizations will operate under the first noted name and a general expansion program is planned, to include the construction of transmission lines for interchange of service between the two systems and for commercial operations at an increased number of communities. It is also planned to construct a steam-operated electric generating plant of super-power type before the close of the year, on site to be selected in the near future.

On June 13, Professor A. G. Christie of Johns Hopkins University sailed for England to be engaged in consulting work during the summer with British interests.

At Alpena, Mich., permission has been granted the Alpena Power Co. to build a dam across the south branch of Thunder Bay River in Green township.

Central Illinois Public Service Co., has renewed its 20-yr. franchise with the city of Taylorville, Ill.

Peoples Power Co., of Moline, Ill., has purchased the outstanding stock of the Rock River Valley Light & Power Co. of Hillsdale for $35,000. The Moline utility has been supplying power to the distributing corporation and the sale included distribution system and business.

Contracts for an addition to the municipal power plant at New Hampton, Iowa, have been let by the city council to house the 625-kw. cross-compound, Murray Corliss generating unit which has been purchased at a cost of $22,581. The addition will be 34 by 40 by 20 ft. and the new equipment will be installed during July.

Seventh Annual short course for metermen was conducted at the University of Illinois, Urbana, Ill., recently, under auspices of the Illinois State Electrical association with a staff of nine special speakers, augmenting the regular class work under direction of Prof. E. B. Paine, head of the Department of Electrical Engineering. The special speakers were: J. W. Murphy, Chicago; E. F. Kelley, Central Illinois Public Service Co., Mattoon; J. C. Wilms, General Electric Co., Chicago; J. C. Langdell, Commonwealth Power Co., Jackson, Mich.; J. E. Bixler, Duncan Electric Manufacturing Co., Lafayette, Ind.; E. D. Doyle, Leeds and Northrup, Philadelphia; B. R. Hill, Westinghouse Electric and Manufacturing Co., and W. C. Downing, Sangamo Electric Co., Springfield.

At the Commencement of Stevens Institute, to the presidency of which Dr. Harvey N. Davis has been elected, Dr. Davis stressed, in his address to the graduating students, the importance of self-education under present conditions. He stated that most education comes after graduation and the diploma is a label denoting that the student has learned how to learn and has professional potentialities.

The honorary degree of L.L.D. was conferred on Dr. Davis during the exercises, also the honorary degree of D.E. upon Dr. Frank L. Sevenoak, who has been acting president of the Institute.

Production of electric power by public utility plants in the United States reached a total in April of 6,846,954,000 kw-hr., an increase of 5 per cent over the out-

put for April, 1927, according to a recent report by the Geological Survey. Of the total amount, 3,907,337,000 kw-hr. were produced by fuel and 2,939,617,000 kw-hr. by water power.

Books and Catalogs

STORAGE BATTERIES, by Morton Arendt, E. E., D. Van Norstrand Co., 8 Warren St., New York; 285 pages, 156 illustrations; 6 by 9 in., cloth, $4.50.

Starting with the principles and history of the storage battery, this treatise discusses lead plates and their manufacture, electrolytes, the lead storage cell, and factors influencing capacity and efficiency. Chapters are devoted to installation and operation, to testing, to applications and to the nickel-iron-alkaline cell.

While theory and chemical reactions are fully discussed, the chief emphasis is placed on what the engineer who is using batteries wants to know in order to operate satisfactorily. When and how to charge, what load may be carried, what conditions will injure the battery, the causes and remedies for "diseases" of batteries and how to secure most efficient and effective service.

INDUCTION MOTOR PRACTICE, by A. M. Dudley; 233 pp., illustrated; 6 by 9 in., cloth, $2.50; McGraw-Hill Book Co., Inc., 370 7th Ave., New York, 1928.

Written for operating men and students, this book gives a clear explanation of the rotating field and transformer actions involved in the induction motor, also of the characteristics and adaptability of squirrel-cage and wound rotor types. Details of construction and the why of them are explained, methods of starting and speed control and considerations which should govern the choice of a motor.

Study of the circle diagram to determine performance is shown and examples are given of its use.

Concluding is a question box of problems that have arisen in motor operation, with full solutions. For the man who wishes to understand or has charge of operation of induction motors, it is a well worth while book.

CHEMICAL ENCYCLOPAEDIA, by C. T. Kingzett; 807 pages; D. Van Nostrand Co., 8 Warren St., New York, N. Y.; price, $10.00.

An epitomized digest of chemistry and its industrial application in a carefully cross indexed and alphabetical form useful as a work of reference by professional chemists, students, and engineers. The subject matter comprises pure physical and applied chemistry, descriptions of the elements and their chief compounds, both organic and inorganic, the methods of their preparation, character and uses, brief accounts of ores and other natural products, together with their utilization and the more important chemical terms and series. In this fourth and latest edition, increased attention has been given to chemical industries and the applications of chemistry in trade. The work is unusually complete and well arranged, containing an extensive fund of condensed and up-to-date information.

SULLIVAN Angle Compound compressors of capacities from 300 to 5100 cu. ft. of free air per min. are described in a new bulletin, No. 83-J. In addition to the general description of the angle compound machine, the bulletin, which is 6 by 9 in. in size, 32 pages, has illustrations of installations of the machine operated by direct connected Diesel engine, by short center belt drive from electric motor, by direct connected motor drive, in both single and twin units, including some units operated by magnetic clutches, and others equipped with stop and start control. The "Multi-step" system of load control, a distinctive feature of these machines, is described in this bulletin, which may be had on request from Sullivan Machinery Co., 122 S. Michigan Ave., Chicago, Ill.

LOPULCO UNIT SYSTEM for burning pulverized fuel is described in a new catalog which contains illustrations and text covering the various types of horizontal, vertical and tangential burners used with this system, as well as a number of interesting application drawings and a discussion of furnace design. Readers interested can secure this catalog by writing to Combustion Engineering Corp., 200 Madison Ave., New York, N. Y.

A. S. M. E. OR BETTER BOILERS is the title of an article by F. O. Pohmeyer in April issue of the Safety Valve, published by Heine Boiler Co., 200 Madison Ave., New York, N. Y.

THE MAY ISSUE of Mine and Quarry, published by the Sullivan Machinery Co., 122 S. Michigan Ave., Chicago, contains interesting articles on the mining of anthracite, showing the methods used in tunneling and loading; on the quarrying of paving blocks in Georgia; on the testing of underwater strata in Miami Harbor; and other uses made of compressed air and compressed air machinery.

LA MONT STEAM GENERATORS employing the principle of film evaporation are described and illustrated in a recent 4-page leaflet by the La Mont Corp., 200 Fifth Ave., New York City.

CENTRIFUGAL PUMP USERS' GUIDE for June, 1928, containing a list of pumping units for prompt shipment to suit various requirements, has just been issued by Allis-Chalmers Mfg. Co., Milwaukee, Wis.

BUSCH-SULZER Type E, 2-cycle Diesel engine is described in a pamphlet just issued, which illustrates installations and details and gives dimensions of engines with three to eight cylinders. The catalog is from Busch-Sulzer Bros.-Diesel Engine Co., St. Louis, Mo.

BROADENING MACHINERY MARKETS and Increasing Shop Efficiency Through Modern Financing Methods is the subject of a recent booklet issued by Machinery Division of Commercial Credit Companies, Baltimore, Md.

AMERICAN STANDARDS for cast-iron pipe flanges and flanged fittings, for pressures of 125 and 250 lb. per sq. in. gage, have recently been issued as Publications B-16-A and B-16-B by American Engineering Standards Committee, 29 W. 39th St., New York City.

ANNOUNCEMENT OF the Course in Fuel Engineering in the Mechanical Engineering Department, Towne Scientific School, University of Pennsylvania, Philadelphia, Pa., beginning Oct. 1, 1928, is made in a recent catalog sent out by the school. This contains description of courses, lists of lecturers and data regarding expenses.

Power Plant Construction News

Ala., Athens—The Volunteer Knitting Mills, Chattanooga, Tenn., plans installation of power equipment in a proposed new local mill unit reported to cost close to $100,000. E. M. Thomason is president.

Ark., Hot Springs—The Hot Springs Public Utilities, Inc., 915 Central Street, plans extensions and improvements in power plants and system, including additional equipment. A fund of about $40,000 is being arranged for the work. S. E. Dillon is general manager.

Calif., Los Angeles—The Illinois-Pacific Glass Corporation, Fifteenth and Folsom Streets, San Francisco, will install power equipment in a new plant unit at Vernon, near Los Angeles, to cost $400,000. Engineering department of company is in charge.

Colo., Devine—The Public Service Co., of Colorado, Denver, in conjunction with the Prairie Oil & Gas Co., Independence, Kans., is reported planning the construction of a new gas compressor plant in the vicinity of Devine, near Pueblo, to cost more than $300,000 with equipment.

Conn., Hartford—The Royal Typewriter Co. will install power equipment in a new five-story factory addition, 70x90 ft., to cost in excess of $250,000.

Fla., Davenport—The Holly Hill Fruit Products, Inc., Davenport, plans construction of an ice and cold storage plant in connection with new local fruit packing factory. A power house is also proposed. Entire project will cost more than $100,000.

Ga., Cartersville—The Georgia Manganese & Iron Co., care of Joel Hurt, Hurt Building, Atlanta, Ga., plans installation of power equipment in connection with a manganese mining and refining plant near Cartersville. Entire project is reported to cost close to $1,000,000.

Ill., Decatur—The City Council plans installation of pumping machinery and auxiliary equipment in connection with proposed extensions in Riverside sewerage plant and system. Entire project will cost more than $400,000. Pearse, Greeley & Hanson, 6 North Michigan Avenue, Chicago, Ill., are engineers.

Ind., Mishawaka—The Major Brothers Packing Co., South Logan Street, plans installation of power equipment in a new three-story packing plant estimated to cost $350,000. The Packers' Architectural & Engineering Co., 431 South Dearborn Street, Chicago, Ill., is engineer.

Iowa, Dallas Center—The City Council plans installation of pumping machinery in connection with a proposed municipal waterworks to cost close to $50,000. W. E. Buell & Co., Davidson Building, Sioux City, Iowa, are engineers.

Ky., Georgetown—The Lexington Utilities Co., Lexington, Ky., is said to be concluding negotiations for purchase of plant and system of Georgetown Water, Gas & Electric Power Co., and plans extensions in that district, including transmission line construction.

Md., Baltimore—The Public Improvement Commission is arranging a fund of close to $6,000,000 for extensions and improvements in municipal waterworks, including new pumping station for Mount Royal, Vernon district, to cost $625,000; pumping equipment in Ashburton section to cost $150,000; new pumping plant and reservoir in Curtis Bay district to cost about $80,000; pipe lines, filtration equipment, etc.

Mass., Ayer—The Nashoba Cold Storage Co., care of Haynes & Mason, 280 Main Street, Fitchburg, Mass., architects, is having plans drawn for a two-story cold storage and refrigerating plant to cost close to $60,000 with equipment.

Mich., Detroit—The Midland Steel Products Co., 6660 Mt. Elliott Street, will install power equipment in a proposed new addition to plant to cost more than $175,000.

Mich., Ferndale—Steel & Tubes, Inc., Cleveland, Ohio, is said to be planning the construction of a power house at its proposed local plant, for which tract of land recently was acquired. Entire project will cost in excess of $750,000.

Minn., Minneapolis—The Shaw-Ennochs Tractor Co., Minneapolis, plans installation of power equipment in connection with proposed rebuilding of portion of plant destroyed by fire, June 2, with loss estimated in excess of $100,000.

Miss., Myrtle—The Mississippi Power & Light Co., Jackson, is reported planning the construction of a local steam-operated electric power plant to cost in excess of $60,000.

Mo., Kansas City—The United States Cold Storage Co., 500 East Third Street, is having plans prepared for a six-story cold storage and refrigerating plant on local site, to cost $800,000 with equipment. A. Epstein, 2001 West Pershing Road, Chicago, Ill., is engineer.

Mo., Marshall—The Page Milk Co., Merrill, Wis., plans installation of boiler plant in proposed new milk condensery at Marshall, entire project to cost about $200,000.

N. D., Fargo—The Great Northern Railway Co., St. Paul, Minn., has approved plans for the construction of a power plant at its local locomotive and car shops and will soon begin work reported to cost close to $40,000. T. D. McMahon is company architect.

Neb., Gering—The Union Pacific Railroad Co., Omaha, Neb., plans installation of power equipment in connection with new engine house, shops, etc., at Gering. A pumping plant will be installed. Entire project will cost about $160,000.

N. J., Paulsboro—The Vacuum Oil Co., 61 Broadway, New York, will install power equipment in connection with extensions in local refining plant to cost about $175,000.

N. Y., Little Falls—Hansen's Laboratory, Inc., manufacturer of food products, will install power equipment in a proposed addition to plant to cost about $250,000 with machinery. C. Haug & Son, Burrell Building, Little Falls, are architects.

N. Y., Mechanicsville—The West Virginia Pulp & Paper Co., 200 Fifth Avenue, New York, will install power equipment in connection with an expansion and improvement program at local mill to cost about $500,000. The Morton C. Tuttle Co., Park Square Trust Building, Boston, Mass., is engineer.

N. S., Halifax—The Drury Co., Montreal, Que., has approved plans for the construction of a four-unit cold storage and refrigerating plant on local site, reported to cost $2,000,000, with equipment.

Ohio, Barberton—The Seiberling Rubber Co., West Hopocan Avenue, plans installation of power equipment in a proposed three-story addition estimated to cost about $140,000. F. A. Seiberling is president.

Ohio, Portsmouth—The Selby Shoe Co. plans installation of power equipment in a proposed five-story addition to cost in excess of $175,000. The H. K. Ferguson Co., Hanna Building, Cleveland, is engineer.

Ont., Leamington—The H. J. Heinz Co., 1062 Progress Street, Pittsburgh, Pa., plans the construction of a power plant in connection with new food products plant at Leamington, entire project to cost more than $100,000.

S. C., Gaffney—The Gaffney Mfg. Co. will install power equipment in a new three-story textile mill, entire project to cost more than $175,000. Lockwood, Greene & Co., Charlotte, N. C., are architects and engineers.

Tenn., Memphis—The Plough Chemical Co., 121 South Second Street, will install power equipment in a new multi-story plant unit to cost more than $500,000.

Texas, Houston—Eternit, Inc., 225 South Fifteenth Street, Philadelphia, Pa., is reported planning the construction of a power house at its proposed new plant for manufacture of asbestos shingles, near Houston, entire project to cost more than $1,000,000.

Texas, Houston—The Burton Packing Co., Houston, plans installation of cold storage machinery and power equipment in a proposed new meat-packing plant to cost about $100,000. Site has been selected at Clark and Bay Streets. Albertson & McFarland, Stewart Building, Houston, are architects.

Texas, San Benito—The Central Power & Light Co., San Antonio, plans extensions in local steam-operated electric power plant including installation of 10,000 kw. turbo-generator and auxiliary equipment to cost more than $350,000, with transmission lines.

Wash., Port Townsend—The National Paper Products Co., operated by the Zellerbach Co., Sacramento, Calif., will install power equipment in proposed new unit at its local mill, entire project estimated to cost more than $1,500,000.

Wash., Yakima—Sellers & Stone, Yakima, have filed plans for the construction of a one-story cold storage and refrigerating plant at 302 North First Avenue, estimated to cost close to $100,000, with equipment.

Wis., Loyal—The Lakeside Cheese Co., Plymouth, Wis., will construct a boiler plant in connection with proposed new factory at Loyal, entire project to cost close to $100,000.